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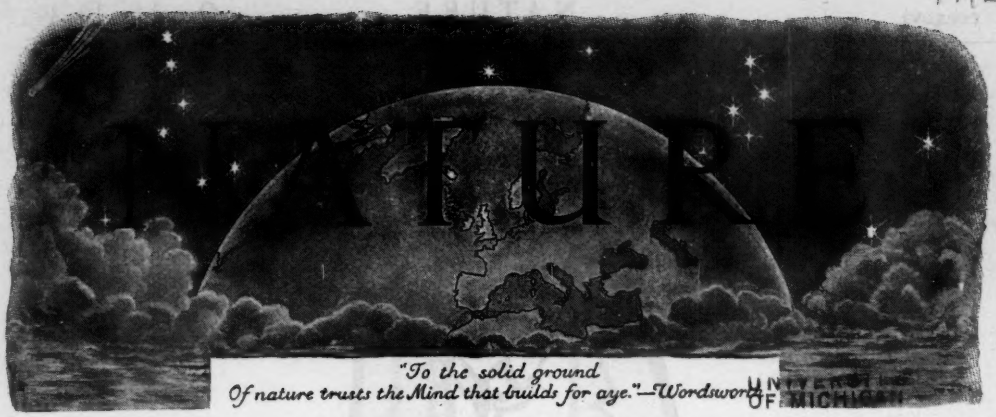

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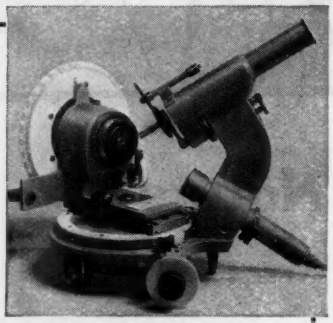

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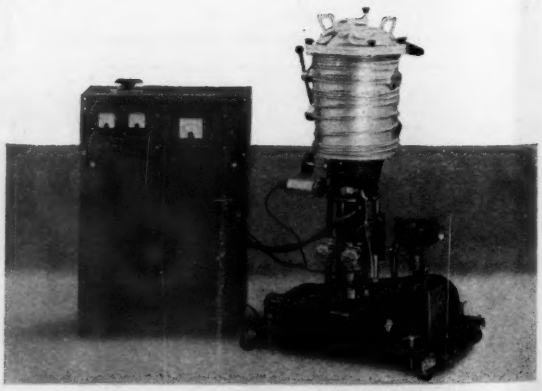

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NATURE

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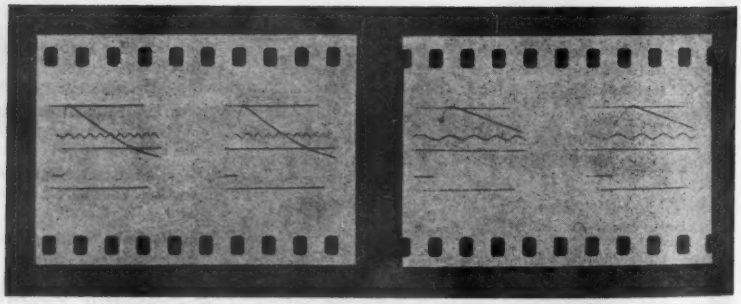

(a) (b)

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THE ARTIFICIAL EARTH SATELLITE

THE fact that the U.S.S.R. has been the first to launch successfully an artificial satellite cannot enhance Russia's political prestige, for fundamentally politics had nothing to do with this scientific achievement. We have no reason for believing that Russian politicians are any more scientifically trained than they are in the West. Neither does this brilliant piece of technology necessarily enhance the status of Russian scientists in the world of science, except perhaps among those who subscribe to the worship of priority in the world of scientific discovery. Moreover, reports that some people in the Western democracies, especially the United States, are expressing fear for the future of world peace as a consequence of this recent news should be treated with the contempt that it merits. This hysterical reaction is a clear symptom of the disease of lack of appreciation of scientific knowledge or its significance, from which many people are suffering to-day.

Apart from demonstrating the efficiency and high standard of scientific research and technical achievement in the U.S.S.R. (a demonstration unnecessary to men of science, but possibly of use to many ill-informed politicians), the most significant feature of this incident is that it reveals how much Russian scientists enjoy financial support, privilege and prestige to a degree much higher than is accorded to their colleagues in most of the democratic countries.

It is not good for science in general that the Russian achievement should be looked upon as a political set-back for the West; neither should it be credited to the U.S.S.R. that she has won a race against the United States. Science flourishes in an atmosphere of encouragement and respect; racing for priority does little or no good. The search for the truth in its own materialist way should be the main objective of science; that is, dispassionate discovery. But in an age of science and technology our men of science must play a more active part in controlling and guiding the social applications of their work. This cannot be done while men of science are treated by too many people in authority as hens in a battery—producing 'eggs' for the use of other people and with little or no say in their disposition.

Accusations have already been made against Western politicians and Service authorities that they have impeded scientific research. This may well be true. It is certainly true that Service 'brass hats' tend to condescend to scientists, sometimes even treat them with contempt; this is due to their lack of knowledge of science. (It is reported that on hearing the news of the Russian achievement, one senior man in the Services retorted that anybody could launch a hunk of iron into outer space. A member of Parliament commented: "If the Russians like to squander untold millions of pounds on moonshine, then that's their funeral". The sincere man of science is dedicated to his work, and in such a vocation encouragement and, above all, respect must be accorded to him by all and sundry. This cannot be, however, in a community where the attitude towards science is one of using it as a tool for political and diplomatic intrigue. Neither can men of science be expected to give of their best when they are treated with condescension or are controlled by people who do not understand what they are controlling.

Often enough recently we have listened to pleas that men of science, especially those in industry and government concerns, should be able to see clearly before them a seat in the board room or among the hierarchy of councils; and, indeed, some of our most successful industrial firms now ensure that the scientists on whom they depend so much shall be offered all the prospects that any other efficient man may reasonably expect.

But among the lay public, this attitude is still very much lacking. Indeed, there are still too many people prone to condemn the scientists for all the world's ills and far too many who openly boast of their lack of knowledge of science and its social applications. It should be no cause for wonder that there is a shortage of scientists or that there is so much apathy and lack of interest in things scientific in any community where the most important schools are encouraging the majority of their best scholars to take up politics, diplomacy, business, etc., or even enter the Church, with a background of political history, economics and the arts but with little or no training in scientific method or appreciation. Perhaps the democratic countries, especially Britain, will show signs of improvement and ability to take their lead in world affairs when the superior attitude of politicians and Service authorities is undermined or modified, when more headmasters in our schools are expected to be trained scientists rather than historians and classicists, and, above all, when the public and the popular Press ceases to look upon scientists as (to use the all-too-common ugly appellations) 'back-room boys' or 'boffins'.

There is no such thing as communist science as distinct from capitalist or democratic science; but there are Russian scientists, and some of them are to be congratulated on this recent brilliant addition to knowledge and achievement. In other countries it might now well be conceded that men of science should be given every conceivable encouragement, which includes higher status and respect; and those States which subject scientific research to false economies should deeply ponder the wisdom of such a policy. (See also p. 734 of this issue.)

THE BALANCE OF GOVERNMENT SCIENTIFIC RESEARCH IN BRITAIN

THE forty-first annual report of the Advisory Council for Scientific and Industrial Research (see p. 726 of this issue) is the last to be prepared under the arrangements for administering the Department which ended with the coming into force of the Department of Scientific and Industrial Research Act, 1956. It follows the pattern of recent years, and time will be required to show whether in fact the new Executive Council will prove a more effective instrument than the advisory body it has superseded. Comments in the present report show how fully aware the Advisory Council was of the difficulty of selecting the most profitable programmes on which the available resources can be employed. As the Advisory Council reminded the Chemistry Research Board, the Department has not, and probably never will have, sufficient resources to carry out all the research work which might with advantage be undertaken. An executive body may be better equipped to terminate investigations which have lost their original importance : it is by no means certain that it will be any the better able to select the best projects or to discriminate soundly between the various projects or activities.

Nor is it certain that an executive body can contribute more decisively to the critical problem of securing that adequate resources are continuously at the disposal of the Department. The Advisory Council, in the present report, in admitting that as a Council it is only concerned with a relatively limited field and is not in a position to judge the relative strengths of claims for Government expenditure, or for the nation's scientific man-power, on civil and on defence research, seems to lean over backward in toning down a passage in last year's report. It now comments that, while the Council has pressed the claims of the Department's work upon the Privy Council, it is discontented rather than intensely satisfied with a situation which is easily remediable by the allocation of additional resources. It deplores the slowing down of the Department's programme of planned expansion caused by the reduction of £150,000 in the Department's estimated net expenditure for 1956–57, and urges very strongly the very early resumption in full of the Department's building plans ; but it does not point out sufficiently strongly the serious effect of such interruptions in the work of a scientific department.

What needs to be emphasized is that Britain may have to pay a very high price indeed for the interruption to a planned scientific programme by economies that are in themselves relatively trifling. The benefits to be reaped from the Department's expansion are long-term in character and not available for some time after the planned expansion is complete. Only something much more serious than is disclosed in the Advisory Council's report can justify the interruption in that expansion necessitated by the reduction in the Department's own vote, the postponement of its building projects and the reduction in the provision in the Ministry of Works votes for services to the Department. Once the planned expansion is approved, the resources for its completion should be made available and secure against anything except the gravest of national emergencies.

The position and authority of the Lord President of the Council, as the Minister generally responsible for the supervision, if not co-ordination, of the scientific effort of the nation, and more especially its research effort, are involved in this matter. That responsibility has been somewhat curtailed by the transfer to the Prime Minister on April 2, 1957, of his functions with regard to nuclear energy by an order made under the authority of the Ministers of the Crown (Transfer of Functions) Act, 1946. The same point arises, moreover, in respect of three other matters which are discussed by the Advisory Council in this report.

The first of these is that of the various kinds of scientific grant made by the Department, in which several changes of policy have been made during the year. Hitherto, the Advisory Council has been advised in regard to these schemes by its Scientific Grants Committee and its Nuclear Physics Committee. The scope of the Department's Special Research Grants scheme is now being extended to cover grants for the purchase of special equipment when it is required for the efficient conduct of a general line of research by a team deserving of special support and not only, as now, when it is required for a particular research project of exceptional timeliness and promise. Moreover, the Department is now to take over the responsibility for making postgraduate awards in science and technology made at present in England and Wales by the Ministry of Education and the local education authorities.

The responsibilities arising from this decision will be greater in view of the expansion in scientific and technological education on which the Government has also decided, and, like the extension of the scope of the Special Research Grants Scheme, their efficient administration requires close co-operation with the universities themselves. The Scientific Grants Committee has already undertaken a thorough review of its selection procedure for maintenance awards, and in doing so entered into close consultation with the Committee of Vice-Chancellors and Principals. The Advisory Council believes that in consequence a procedure has been worked out which should not only give satisfaction both to universities and other

institutions and to individual applications, but should also make the best use of the time of the members of the Committee and the other scientists who assist the Department in this task.

This review strengthened a growing opinion that the existing division between a Scientific Grants Committee and a Nuclear Physics Committee was not the most suitable arrangement under current conditions, and the Council decided accordingly to separate responsibility for the maintenance allowance and senior research award schemes on one hand from that for the scheme for special researches, including nuclear physics research, on the other, and to set up in place of these two committees a Postgraduate Training Grants Committee and a Research Grants Committee. The decision is obviously sound, if only because it should promote the apportionment of research effort between the different fields. It is the high cost of nuclear physics research which has led the universities to look to the Department for assistance in this field. As the Advisory Council remarks, the heavy and largely unpredictable cost of running large machines for accelerating nuclear particles has made it difficult to provide for them from the universities' quinquennial budget; but although the Department has made an exception to its normal practice of limiting grants to the initiation of research, the position has been reviewed, again after discussion with the University Grants Committee. The Department will continue to provide support on a year-to-year basis, but the support will be limited to the maintenance of the machines and the provision of technicians and cost of electric power, cooling water and refrigerants required to produce a beam of particles.

Here again we see how closely in practice the work of the Department touches that of the University Grants Committee, and the importance of ensuring that at some point in the national administration it should be possible to obtain a conspectus of the distribution of the nation's research effort and of the resources available. It would appear, for example, that this year it has only been possible to make all the scientific grants, recommended by the Councils' two committees as justifiable on account of their timeliness and promise, because of savings on activities elsewhere in the Department. Further, since the Lord President's office is exceptionally well placed to obtain the necessary conspectus of resources, it would seem more logical to extend his responsibilities rather than curtail them. Nuclear research, for example, may well be even more closely interlocked with the research work of the universities, as well as with industrial research, as the development of nuclear energy proceeds, and no review of the national research effort and resources can ignore what is being done by the Atomic Energy Authority.

This is a matter which could well engage the attention of the new Council, though the prime responsibility lies higher up. There is, however, another aspect with which the Council should be closely concerned. One of the Department's major grants was £230,000 to the University of Manchester towards the cost of the radio telescope under erection at Jodrell Bank and of the current programme of radio-astronomy. Now it is learnt that the estimate of £439,616 in May 1953 is likely to be exceeded by more than £250,000. This project is regarded as of such scientific importance that the Advisory Council has recommended a further Government grant of up to £130,000 to help meet this deficit; but in the meantime the Public Accounts Committee has strongly criticized the lack of control of this expenditure.

This is not the place to discuss the matter in detail, but it does illustrate a major difficulty in scientific projects in a rapidly developing field. Fine judgment is required if full advantage is to be taken of continuous scientific advances which are made during the progress of a building project extending over the better part of a decade; but the Department of Scientific and Industrial Research is criticized quite reasonably for not watching the actual expenditure more closely. The Committee of Public Accounts makes the sensible recommendation that, in future, when Government departments entrust substantial grants to universities for specific purposes, they should seek the advice of the University Grants Committee on such matters as definition of contracts, establishment of university sub-committees responsible for the execution of the project and any other measures necessary to control and supervise capital expenditure.

This recommendation seems to indicate that this lapse has not stimulated fresh criticism of the University Grants Committee itself. On the contrary, earlier in this same report, the Committee of Public Accounts, commenting on the Treasury Minute of January 31, 1957, and welcoming the extent to which the Treasury has sought to meet its wishes in regard to non-recurrent grants to the universities, recommends that the new arrangements for control of the expenditure of such grants should be given a three-year trial. It is to be hoped that the argument which the Committee of Public Accounts has maintained for a full decade has been brought to a satisfactory issue without invading university autonomy. It might, however, be well worth while for the new Council for Scientific and Industrial Research to give some attention both to this question of accountability generally, as well as to its own relations with the universities, and to the allied question of ensuring that expenditure on scientific projects once sanctioned is not liable to reduction by passing calls for economy in general.

The other two matters also both relate to the disposition of the Department's resources. The Department has now been made responsible for the National Science Lending Library and is to take over the administration of the nucleus scheme. The Advisory Council agrees that such responsibility can appropriately be given to the Department, but it rightly points out that the development and maintenance of such an institution should not be expected to fall

on the Department's present resources for research. There is no indication that the Government has as yet allocated any resources for the new library, nor does the Advisory Council refer to the related matter of a National Reference Library for Science and Technology, which was no less strongly recommended by the Advisory Council on Scientific Policy. The two projects are intimately related, and unjustifiable squandering of precious resources is inevitable if both projects are not planned and developed simultaneously, or indeed if they are not planned as part of a Science Centre.

The exchange of an advisory for an executive body will scarcely be worth the effort if the new Council is unable to make strong representations to the Government on the futility of such parsimony, or to direct attention to the great advantages which will result from prompt action on the recommendations of the Advisory Council on Scientific Policy. Although the advice of the latter body has so far been disregarded, the new body could urge a fresh point of view on the Government, and is at least entitled to protest, alike at the failure to provide the Department with the resources required for the scheme now approved by the Government and at the waste inherent in the Government's proposals. Already, as this report shows, the preliminary planning is making some demands on the resources of the Department's Intelligence and Information Division, although the Russian Literature Centre which it is proposed to create as the first instalment of the National Science Lending Library appears to be in line with recent activities of that Division.

A large proportion of the work of that Division is now concerned with social and economic matters, such as human factors in industry, automation and the study of industrial operations ; and the reference to social and economic research in the Advisory Council's report raises the question of the apportionment of the Department's resources in that field, as distinct from industrial research in the usual sense of the word or research in the physical or biological sciences, pure and applied, with which for long the Department was exclusively concerned. The bearing of such effort on industrial productivity is not questioned, but it would be appropriate to have some picture of the national expenditure in this field ; there is no clue in the Department's report as to the magnitude of even its own expenditure in this connexion. Some of the work is obviously being done by the research associations, but although it may be difficult to gain an exact idea of the total effort, some approximation is obviously desirable. It is scarcely dignified for it to be unknown, in view of the help that has come from the United States under Conditional Aid ; and the termination of that Aid in 1956, to which the Advisory Council refers, makes it the more desirable to estimate the magnitude of our effort, if only as a basis for judging the soundness of the Advisory Council's proposals for further investigations both on human relations in industry and on individual efficiency in industry. The Advisory Council has already reviewed the position and suggested discussions with the Medical Research Council, which was jointly responsible for setting up the two committees. It has also appointed a Committee on Economics and Industrial Operations, with Prof. E. A. G. Robinson as chairman, to keep under review the work in progress in the Economics Section and Industrial Operations Unit of the Headquarters Intelligence Division, to examine current and future requirements covering the general study of industrial operations and the economic factors affecting productivity, research and the application by industry of the results of research, and to make recommendations for work in these fields to be undertaken or supported by the Department.

This is a large question on which the new Council clearly must take early decisions as to general policy and programme ; but the time appears to be ripe for consideration at a higher level of the nation's effort in this field and how far it should fall within the scope of the Department. A strong case could be made for entrusting the responsibility for social and economic research to an independent body, in the same way that medical research is the responsibility of the Medical Research Council and agricultural research of the Agricultural Research Council. This is not to suggest that the Department should not undertake such research : it is too closely interlocked with the broad question of productivity and of ensuring the effective utilization of the results of scientific research for a sharp distinction to be made. Nevertheless, some caution and forethought appear to be called for, just as they are in the field of education, to which also the Department makes an important contribution, notably through the research associations.

There is, of course, a considerable variation between the research associations in this respect, which in turn is reflected in their varying status and their experience in obtaining support from the industries they serve. Nor is it simply a matter of whether the industry has its own tradition or practice of research, or whether it tends to lean heavily or exclusively on the research association. The education of an industry in the application of science does not proceed simply through the supply of research results or of trained scientists—the latter being an important aspect of the research associations' contribution to higher technological education. It is a matter also of the staffing of the industry at its higher levels with men competent to assess the significance of scientific and technical advances for the processes and products of the industry—a matter which goes far beyond the supply of information or of scientists and technologists.

What is increasingly essential is that a continuous review of the functions of the Department should be undertaken in relation, not simply to the country's effort in research generally, including medical and agricultural research as well as university research and social and economic research, but equally to its contribution to technological education, the training of scientific and technical man-power, and information

services, productivity and the like. For this task the Lord President of the Council and his office occupy a key position, as appears from a survey made by a study group of the Royal Institute of Public Administration recently published under the title "The Organization of British Central Government, 1914–1956". The chapter on scientific research in that volume brings home, however, just as emphatically as the valedictory report of the Advisory Council for Scientific and Industrial Research, that the overriding need of the moment is for some authority competent to hold in broad review the nation's effort in these varied but related fields, to assess the significance of the recommendations of the various councils and to keep the distribution of the available resources in balance with the varied needs; it must also be strong enough to present the claims so that they receive full consideration in relation to those of defence, social services and the other sectors of the national life. Much of this could be done by the Advisory Council on Scientific Policy or through the Lord President if the existing powers and responsibilities were discharged in their entirety. On the evidence of the present report from the Department of Scientific and Industrial Research, it can no longer be pretended that the existing arrangement is satisfactory. While the activities of the new Executive Council for Scientific and Industrial Research will be followed with interest and goodwill, it is clear that the Department cannot be expected to make its full contribution to the national welfare and to industrial advance unless this lacuna is made good. There should be, at Cabinet-level, the means for assessing accurately the Department's work in relation to other effort calling for scientific and technical resources, competent to secure a reasonable balance, and strong enough to ensure that the resources made available for such effort are both adequate and undisturbed.

DEVELOPMENT OF INDUSTRIAL CHEMISTRY

A History of Industrial Chemistry

By Dr. F. Sherwood Taylor. Pp. xvi+467+22 plates. (London: William Heinemann, Ltd., 1957.) 30*s*. net.

TO give an outline in moderate compass of the origin and development of industrial chemistry is a formidable task, entailing a balanced survey of a vast and complicated field in which pure chemistry and applied chemistry, both in a state of almost explosive expansion, are inextricably interwoven. Such a task could be undertaken successfully only by a writer of the exceptional calibre of the late Dr. Sherwood Taylor, in whom a scholarly outlook, a facility of expression, and a profound knowledge of the historical, theoretical and industrial aspects of chemistry were so happily blended.

Until the opening of the eighteenth century there was little connexion between chemical theory and the application of chemical knowledge; but from the middle of that century onwards the liaison between these two aspects of chemistry has grown ever closer. That is why the author found himself compelled, as the work progressed, to devote an increasing attention to the history of chemical theory.

The character of a book of this kind is perhaps determined as much by the arrangement of the material as by selection and emphasis. In the present instance, a short introductory survey of chemical industry precedes the two main parts of the book, which are concerned respectively with the pre-scientific and the scientific chemical industries. The eleven chapters of Part 1 are devoted to a consideration of important materials and processes, including metallurgy, ceramics, glass, combustibles, dyeing, and pharmacy. The thirteen chapters of Part 2 trace the concomitant progress of theoretical and applied chemistry, some of the main heads being scientific chemical industry, 1788–1860, the rise of theoretical organic chemistry, industrial organic chemistry, biochemistry, the discovery of the chemical elements, the road to nuclear power, the arrangement of molecules, electrochemical industries, the conditions of chemical reactions, and industrial gas-reactions.

The book is thus in effect a compact encyclopædia of the subject, written, however, in a lucidly flowing and attractive manner. It will open many new windows to readers having a thorough fundamental knowledge of chemistry; while the specialist may use it as a handy *vade mecum* from which, by virtue of a comprehensive index and a classified list of more than two hundred works of reference, he may gain more detailed information upon any matter of a historical, theoretical, or industrial nature in which he is particularly interested.

A high standard of accuracy is maintained throughout, and the matter is well up to date; but a few of the many points which naturally invite critical comment in a work of this wide scope may be mentioned. Although the author justifiably emphasizes principles rather than men in this treatment, he might well have given some credit to Glauber as an outstanding pioneer of applied chemistry. *Inter alia*, Glauber obtained coal-tar distillates as early as 1648, well in advance of Becher and Searle's "patent for making pitch and tar from coal in furnaces as early as 1681". It is somewhat surprising also to find no mention of John Clayton and his remarkable experiments (of which detailed accounts exist) with coal gas about the year 1687, although it is stated that "several persons seem to have experimented with coal gas during the [seventeenth] century".

Turning to a very different subject, the drawings on p. 222 purporting to be illustrations of crystals were described in my hearing many years ago by an irate stereochemist as "recurrent bow-windowed monstrosities". Moreover, it may be pointed out that "the sodium ammonium salt of racemic acid", which they are described as representing, forms monoclinic crystals quite distinct from the hemihedral rhombic crystals of the enantiomorphous sodium ammonium tartrates.

The profuse illustrations range from beautifully reproduced engravings after Agricola, Ercker, Biringuccio, Braunschweig, and still earlier sources, to the *dernier cri* represented by the frontispiece of the Windscale plutonium-producing factory. The type, paper, and format are excellent, and all concerned are to be congratulated on producing this attractive and valuable volume at so moderate a price.

JOHN READ

NEUROPHYSIOLOGY AND THE INTRACELLULAR TECHNIQUE

The Physiology of Nerve Cells

By Prof. John Carew Eccles. Pp. xi+270. (Baltimore, Md.: The Johns Hopkins Press, 1957.) 5.75 dollars.

THIS book, based on the Herter Lectures delivered at the Johns Hopkins University, presents the latest development of the fundamental work by Prof. J. C. Eccles and his colleagues at Canberra on the properties of motoneurones as revealed by the intracellular technique of electrical recording. His earlier book, "The Neurophysiological Basis of Mind" (Oxford University Press, 1953), was written for a broad circle of readers. The new book is something of a supplement for neurophysiologists, a thorough exploration of the properties of the membrane of the motoneurone cell body in terms of 'inside' records. The four leading chapters are devoted to this task, the two remaining ones to a discussion of recent work and current ideas in neurophysiology.

The motoneurone cell body, some 70μ across, is penetrated by the tip of a glass capillary 0·5μ in diameter and filled with an electrolyte. In these large cells, situated in the ventral horn of the spinal cord, the wound is reasonably well sealed by the cell membrane, which closes up around the capillary so that reflex excitation and inhibition can be studied in terms of potential changes across the cell body. Some excitatory changes, especially long-lasting ones, are presynaptic and are thus not accessible to this technique, whereas others are determined by events in the cell processes or dendrites and only indirectly reflected in the cell body. Intracellular recording is therefore a technique for studying the 'effector' end in the chain of events, rather than all aspects of central nervous excitation. However, bearing this limitation in mind it has proved a fascinating tool. This approach originated with the Canberra group, and they have followed it up with outstanding skill.

Their most important generalization, since confirmed both for motoneurones and many other cells, still remains the discovery that monosynaptic reflex excitation depolarizes the cell along a characteristic curve, whereas inhibition drives the membrane back towards its equilibrium potential or even hyperpolarizes it. Theoretically, inhibition could also be obtained by excessive depolarization, and this case has been described elsewhere with cerebellar Purkinje cells, but apparently the characteristic responses found by Eccles and his colleagues are common for many types of nerve cells.

The book opens with a thorough account of the electrical properties of the cell membrane, as measured by themselves and others, and then proceeds to a presentation and discussion of the results obtained with double-barrelled microelectrodes. One barrel is used for changing the level of membrane potential by electrophoretic injection of anions or cations, while the other records the membrane potential and the effects of reflex excitation and inhibition. These difficult and skilfully conducted experiments are also hard to interpret in physicochemical terms, but nevertheless represent an approach to the problem that had to be carefully explored. They gave very valuable information on the generation of an impulse or spike in relation to level of membrane potential. Both excitation and inhibition will be found analysed in the book from these points of view. The fundamental line taken is that excitatory or inhibitory synaptic mediators or transmittor substances initiate the flow of ions, culminating in the excitatory or inhibitory changes of membrane potential studied. The rhythmic discharge of spikes is found to emanate from the region around the excitor axon hillock of the motoneurone, which seems to be specialized for the emission of signals down the axon.

The experimental work presented in this book has required not only skill but also patience and industry far beyond the ordinary. It is a pioneer effort rewarded by real insight into the electrical properties of nerve cell bodies and it has stimulated much research in many other centres throughout the world. Prof. Eccles does not shun discussion, so that the well-informed student of the central nervous system will find much more in the book than the presentation of a new line of approach to the physiology of nerve cells.

RAGNAR GRANIT

THERMODYNAMICS AND THE STRUCTURE OF MATTER

Thermodynamics and Statistical Mechanics

By A. H. Wilson. Pp. xv+495. (Cambridge: At the University Press, 1957.) 50*s*. net.

THERMODYNAMICS and statistical mechanics are commonly treated as separate subjects. They are, however, so closely connected that there is great advantage in treating them in a single book, as is done here. Six of the fourteen chapters are devoted to development of the fundamental theory, and the other eight to various applications.

In the first three chapters thermodynamics is developed in the classical manner. Now thermodynamics is a subject that is much easier to apply than to develop. Its historical development, which has happened in an illogical order, has added to the difficulties. Accounts of the first principles of thermodynamics are therefore often confused, and contain concealed assumptions or even circular arguments. Dr. A. H. Wilson has here given a clear account of the classical theory with all the assumptions precisely stated. But the classical development of thermodynamics, however well described, is not completely logically satisfying; in the fourth chapter, therefore, Dr. Wilson describes Carathéodory's axiomatic approach. Readers may choose, therefore, between the more logical approach of Carathéodory, and the less abstract one of the classical method; but there would be advantage in reading both accounts.

Chapter 5 discusses the foundations of statistical mechanics. As with thermodynamics, this is the most difficult part of the subject; application to a particular problem is simple by comparison. There are several possible methods of approach. Dr. Wilson starts by considering quantal systems; his fundamental assumption is that the value of any dynamical variable of a macroscopic system is obtained by taking the average of the variable over all the possible stationary states of the system. The relations of temperature, entropy, etc., to the energy-levels of the system are then developed. Use is made of Stirling's theorem, but Dr. Wilson is careful to point out the problems and difficulties involved in this.

Reference is then made to the Darwin–Fowler method of avoiding the use of Stirling's theorem and to the fundamentally different approach of Gibbs. Classical statistical mechanics is then derived as a limiting case of quantum statistical mechanics.

Chapter 6 gives applications of the formulæ previously obtained to problems of specific heat, and to systems obeying the Fermi–Dirac or Einstein–Bose statistics.

In Chapter 7 there is a return to fundamentals with an excellent account of the third law of thermodynamics; the nature of the underlying assumptions and of the experimental evidence is carefully stated.

The remaining seven chapters are devoted to applications of the theory. The possible applications are so many that only a selection can be made, and no doubt some readers will be disappointed that their particular interest is not dealt with. However, the majority will consider that Dr. Wilson has made a reasonable choice. He has described some of the subjects of a wide general interest to physicists and physical chemists, such as the theory of imperfect gases, vapour pressures, magnetism, chemical equilibrium, solutions, and electrolytes; and has also discussed some of the more recent problems, which are not discussed in the older books on statistical mechanics. Examples of these are properties of liquid helium, superconductivity, antiferromagnetism, ferroelectricity, rubber, and recent work on the order–disorder problem.

This is an excellent book; but though self-contained, it is not a book for the beginner, who would be well advised to start with one of the more elementary treatises on the subject. In the words of the author, it treats elementary matters from an advanced point of view and is suitable, therefore, for the student who has a basic knowledge of the subject and is anxious to put it on a sound logical foundation. Those engaged in research in one of the specialized topics dealt with will also be glad to consult it.

A. F. Devonshire

CHEMISTRY OF CO-ORDINATION COMPOUNDS

The Chemistry of the Coordination Compounds

Edited by John C. Bailar, Jr. (American Chemical Society Monograph Series, No. 131.) Pp. x+834. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1956.) 148s. net.

In recent years interest in the theory of co-ordination and co-ordination compounds has developed to a very marked degree, resulting in increasing application to many types of chemical work. Even to those not intimately acquainted with the subject, the use of organic precipitants for metallic ions will surely be familiar. This, however, represents but one small fraction of the application of co-ordinating agents. It could be claimed that, in some measure, the Werner theory of co-ordination published about sixty years ago is the guiding principle of our modern theories of acidity, basicity, hydrolysis, etc. To-day, applications of co-ordination theory are found in the use of co-ordinating agents for the extraction of metals from their ores, in electroplating, in catalysis of reactions, in water treatment and in the study of dyes and pigments. Undoubtedly very many other uses of these compounds await further investigation. The subject, therefore, has both theoretical and practical interest to the chemist in general, whether inorganic, physical or organic, but the lack of an authoritative source book has been an obvious disadvantage.

The editor of the present volume has clearly recognized this need, and, wisely deciding that the task was too great for one man, has produced a most comprehensive work to which twenty-four authors have contributed. The volume is published as one of the American Chemical Society's Series of Chemical Monographs. In the first section of the book the editor and Dr. D. H. Busch give a general survey of co-ordination compounds, the excellent documentation and style of which set the standard for the remainder of the volume. Three very interesting sections follow. In the first of these the historical development of the co-ordination theory is covered, and the following two embrace modern developments, with emphasis on the influence of the electrostatic theory and electron pair bond on the structure of co-ordination compounds. Other topics covered include chelation, and the theory of heterocyclic ring formation involving metal ions, with a separate section on large rings, the stereochemistry of co-ordination numbers 4, 6 and less common numbers, isomerization of co-ordination compounds, the stabilization of valency states by co-ordination, theories of acids and bases, amphoteric compounds as applied to complex substances and olated compounds, that is, complexes in which the metal atoms are linked through bridging hydroxyl groups. Special features include a study of the isopoly- and heteropoly-acids, co-ordination compounds of metal ions with olefins, the metal carbonyls and nitrosyls and organic molecular compounds.

Perhaps the section which illustrates most clearly the extent of the subject, and the comprehensive nature of this volume, is that describing the physical methods employed for the investigation of co-ordination compounds. To say that these are numerous is an understatement: they include X-ray and electron diffraction, tracer techniques, dipole moments, magnetic measurements and dialysis and electrolytic transference, apart from those which are more familiar. In a more applied sense the importance of co-ordinating agents is seen in those sections which survey their uses in analytical chemistry, water softening, electrodeposition and the formation of dyes and pigments. The literature associated with this subject is very large, and the authors have therefore restricted themselves to lists of references which have been critically selected on the basis of their importance and significance. Despite this, however, the number of references is more than five thousand, many of which are very significant for further reading on the subject-matter.

This is an excellent work and contains all the salient aspects of co-ordination chemistry. The emphasis on modern developments is especially valuable. Although the subject has been covered very extensively, a claim might be made for the inclusion of a section on the methods of preparing complex ions, in view of current interest. This book will undoubtedly prove of very great value to chemists and workers in allied fields and can be strongly recommended.

R. J. Magee

THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT FOR 1955–56

THE annual report of the Department of Scientific and Industrial Research for the year 1955–56* includes the report of the Committee of the Privy Council for the year ended September 30, 1956, over Lord Home's signature, and the forty-first, and last, report of the Advisory Council, signed by Sir Harry Jephcott, which includes the customary summary of work carried out by the various research stations and boards and research associations. Besides the summary of the Department's expenditure for the year ended March 31, 1956, there are appended a copy of the Department of Scientific and Industrial Research Act, 1956, under which the present Advisory Council is replaced by an Executive Council, lists of assessors to the Advisory Council, of the various committees of the Advisory Council and their membership, of the research boards and establishments of the Department, of grants for special researches in progress or authorized during the year, of students awarded maintenance allowances for postgraduate training in research and a 49-page list of publications issued during the year.

The gross expenditure of £7,350,738 compares with £6,685,400 in the previous year and is reduced to £6,428,693 by various receipts (£407,222 being from the National Physical Laboratory) for work done for government departments or for industry, the net increase on 1954–55 being £530,677. The Department's net expenditure for 1956–57 has been reduced by about £150,000 as part of the Government's economy campaign, and although the effect of this reduction will be to slow down rather than stop the Department's programme of planned expansion and development, it is deplored by the Advisory Council. Moreover, two building projects—an experimental road system, designed as the first part of a new Road Research Laboratory, and a new chemistry building at the Building Research Station—on which work was to have started in 1956–57 have been deferred, and the Advisory Council urges very strongly the importance of an early resumption in full of the Department's building plans. On October 1, 1956, the Department employed 4,655 staff of all grades (including 200 part-time), compared with 4,379 (190 part-time) in the previous year, and as a result of this increase the deficiencies which had accumulated during the two preceding years have largely been overtaken. Annual grants to research associations totalled £1,423,775 (compared with £1,335,125 in 1954–55), grants for special researches amounting to £373,028 (£315,425 in 1954–55). Grants to students amounted to £319,919, a decrease of £3,103, the number of students in training in 1955 being 1,012, and in 1956, 1,006, and of these, 379 in 1955 and 404 in 1956 were new. Of eight senior research awards in 1955 and seven in 1956, five in 1955 and four in 1956 were new, and 15 new grants for special researches in 1954 and 46 in 1955 brought the total of such grants to 53 and 99, respectively, compared with 58 in 1953 and 64 in 1954. Of the grants for special researches, 33 in 1955 and 54 in 1956 were in physics; for chemistry, the figures were 9 and 14; for biology, 4 and 7; for engineering, 4 and 5; for mathematics and astronomy, 1 and 7; and for geology and mineralogy, 1 and 8. In 1955 chemistry claimed 399, and in 1956 372, of the students receiving grants; in physics the corresponding figures were 262 and 256; in biology, 107 and 108; in mathematics and astronomy, 86 and 96; in engineering, 91 and 42; in geology and mineralogy, 42 and 43; and in chemical engineering and metallurgy, 23 and 58.

Expenditure on the National Physical Laboratory of £946,890 gross or £542,668 net was slightly less than in 1954–55 (£556,435), and there were also decreases in the expenditure on food investigation (from £373,208 to £358,528 net), radio research (from £107,298 to £104,119 net) and forest products research (£116,487 to £116,161); but expenditure on the other branches of the Department's activities increased, the largest increase being in the expenditure on mechanical engineering research (from £315,561 to £436,006). Net expenditure under the other major headings in 1955–56 was as follows, the increase over 1954–55 being given in brackets: building research, £492,701 (£39,652); road research, £388,436 (£44,920); fuel research, £288,260 (£17,841); Geological Survey and Museum, £268,046 (£44,636); Chemical Research Laboratory, £139,226 (£2,876); hydraulics research, £84,046 (£7,877); water pollution research, £76,482 (£2,161); pest infestation, £72,284 (£4,139); fire research, £31,781 (£9,348); headquarters, administration, etc., £272,581 (£24,636), and headquarters, overseas liaison, etc., £76,235 (£5,797).

The contribution to the European Organization for Nuclear Research also increased from £359,787 to £519,996, and while only some £40,000 out of the expenditure of £315,425 net on grants for special researches authorized in the year ended September 30, 1956, was for nuclear research, grants totalling more than £800,000 had been authorized prior to October 1, 1955, for nuclear physics research still in progress, as well as more than £40,000 for equipment.

Those research stations with the work of which the Advisory Council's report is this year specially concerned are the Road Research Laboratory, the Water Pollution Research Laboratory and the Chemical Research Laboratory, all of which were visited by the Advisory Council. The Advisory Council was particularly impressed with this, its first, visit to the new Water Pollution Research Laboratory at Stevenage, and was satisfied that the work is well planned to achieve results of practical value and that co-operation with 'user' interests is outstandingly good. In particular, the Advisory Council believes that in the survey of the conditions in the Thames, undertaken in co-operation with the Port of London Authority, the work of the Laboratory has pointed the way to a proper understanding, of the greatest economic value, of the effects of the manifold sources of trouble in the river, and of their complicated interactions and seasonal variations. The investigations have made it possible to devise reliable methods of forecasting the effects of a new source of pollution or of a new remedial method, and by so

* Department of Scientific and Industrial Research. Report for the year 1955–56. Pp. 314. (Cmnd. 213.) (London: H.M. Stationery Office, 1957.) 9s. 6d. net.

doing have provided a quantitative basis for assessing the best and most economical means for dealing with a problem vital to the health and work of Londoners. Other work of the Laboratory has been concerned with the tolerance of different species of British freshwater fish to low concentrations of dissolved oxygen over the range of temperatures to be expected in British rivers.

In the two main sections of the Road Research Laboratory, a little less than two-thirds of the resources are devoted to problems of road construction and a little more than one-third to safety and traffic. The Laboratory's investigations on the possible economic returns from building new roads appear to be of particular interest at present, and it is expected that the new road construction programme will offer greater opportunities for use of a trial method of assessment which has been worked out. The Advisory Council was impressed with the contribution which the Laboratory's work is making to improving the quality and lowering the cost of road construction and pointing the ways to a smoother flow of road traffic and the achievement of greater safety. As particular examples may be mentioned the Laboratory's study of the effectiveness of the various ways of indicating a turn, including flashing indicators and semaphore arms, now in use on vehicles; of the bearing of street lighting on accidents, and on the development of standards of minimum resistance to skidding for different types of roads; its study of the stabilization of soils with a high clay content, of soil compaction, and of testing techniques for rapidly assessing the quality and thickness of the various layers forming a road and for determining the load-spreading characteristics of the road structure.

The Advisory Council was much impressed with the scientific quality of the work of the Chemical Research Laboratory. The Council emphasizes that the Laboratory is intended to undertake chemical research on selected problems of national interest, and on investigations on lines for which no provision exists in the universities or in industrial laboratories. The emphasis on the importance of careful selection of subjects may be of special significance in view of the change in the organization of the Department under the new Act. In further work on the separation of individual rare earths by ion-exchange methods, the Laboratory has found that improved separations are obtained if the rare earths are diluted with ammonium ions so that they occupy a longer length of the ion-exchange column. Two new instruments have been developed for applying the technique of zone-melting to the separation and precipitation of organic compounds, a new technique has been developed for fractionating high polymers and encouraging progress made in the development of paper-strip chromatography as a micro-method for the determination of molecular-weight distributions of polymers.

An investigation by the Building Research Station has shown that savings in water consumption amounting to more than a million gallons a year with a decrease in solid fuel consumption of more than 50 tons could be achieved in a large office building with a staff of more than a thousand by substituting spray taps (supplying blended hot and cold water) for the normal pillar taps used for washing. Other work of the Station has indicated the possibility of reducing the cost of a flat in a block of six stories or more as much as £450 a flat by combining the economic features of different designs, and research in co-operation with the Midland Regional Board for Industry is endeavouring to provide authoritative data on the most suitable and economic forms of factory design and construction. An investigation into casualties caused by the ignition of clothing, while not yet complete, has indicated the need for increased emphasis on the design of clothing, on the use of fire-guards and on increased care for the young and old, while the textile industry continues its researches on flame-retardant treatments.

In food investigations the potential use of antibiotics in the preservation of fresh foods is being studied experimentally, and the small unit of the Low Temperature Research Station at Cambridge has resumed its studies of the use of ionizing radiations to extend the storage life of selected foodstuffs. For this purpose it has been strengthened by staff seconded from the British Food Manufacturing Industries Research Association and from industry. Other investigations are concerned with the serious wastage in the meat industry from the concealed loss of offal and tissues of the carcass when an animal is being taken to an abattoir and rested before slaughter, the reasons for the marked decline in consumption of smoked fish and the development of improved processes for smoking. Use of nonyl alcohol vapour has been found to provide a simple, effective and cheaper method of suppressing the sprouting of potatoes on a pilot-scale up to 15 tons; and further work on the application of refrigeration and the use of carbon dioxide in the transport of soft fruits has made it possible to specify the conditions required for successful pre-cooking of soft fruits and transport from farm to market.

The Forest Products Research Laboratory is devoting increasing attention to the study of home-grown softwoods, and besides developing simpler and more effective methods of bending for industrial use, has attempted to devise a method of impregnating test samples with low concentrations of creosote while ensuring its uniform distribution. In co-operation with the Atomic Energy Research Establishment, the treatment of infested timber with gamma-rays has received much attention. The Fuel Research Station intensified its efforts towards the efficient utilization of the more plentiful coals, including those of small size and comparatively low quality, and the Station also obtained a correlation between mortality and the observed atmospheric pollution in the different districts of London.

A generous financial grant by the Nuffield Foundation for an airborne magnetic survey to allow assessment of the potentialities of the method and study of alternative techniques permitted a survey of about 11,000 sq. miles in the Midlands, and concurrently magnetic measurements were made at about twenty-five ground stations distributed over the whole of Great Britain. A survey of Norfolk showed that only about 5 per cent of the available ground-water resources are being used; a similar survey is being made in south-east Lincolnshire.

The staff of the Mechanical Engineering Research Laboratory increased by 14 per cent during the year, but the general balance of fundamental and applied research was little changed. The special equipment for basic research on the principles underlying the design of hydraulic machinery has been completed with the erection of a closed circuit for cavitation

research on water-turbines. Much attention is being given to fundamental studies of wear, and a fundamental investigation of the causes of varying adhesion between wheel and rail is being carried out for the British Transport Commission. Two very accurate electric dynamometers have been developed for research on power transmissions, and the Heat Division is attempting to provide more accurate basic design data for conventional and novel types of heat exchanger.

The work of the National Physical Laboratory has recently been reviewed in these columns and no more need be added here than that the Control Mechanisms and Electronics Division is sponsoring the development of auxiliary machinery which would permit the cost of certain clerical tasks to be cut by more than 50 per cent by using types of scientific computer now on the market, and that work in the Ship Division has shown that on the same power output a well painted and a badly painted ship may differ by as much as half a knot in speed. Work on grain storage has shown that quite damp grain, such as may be harvested by combine in a wet season in Britain, can be stored for several months in air-tight metal bins without detriment to use for feeding to stock. The new laboratories at the Radio Research Station, where studies on the propagation of radio waves over a very wide band of frequencies absorbed the bulk of the effort in radio communications research, came into use in June 1956. In radio-navigational aids the effort has now been diverted to much lower frequencies which show promise of being suitable for use at longer distances, while in work on semiconductors an appreciation has been obtained of the dependence on frequency of the noise per unit bandwidth developed in monocrystalline filaments of germanium carrying current, and in back-biased, point-contact and junction diodes.

During the year 1955–56, grants were offered to two new research organizations, bringing the total of grant-aided bodies to thirty-nine research associations, seven research councils or committees not yet of research association status, and three other institutions the activities of which are of special interest to industry. A block grant of £3,000 a year, conditional on £6,000 of grant-earning income from the industry with up to an additional £4,000 on a cent-per-cent basis, was offered to the Heating and Ventilating Research Council for the period January 1, 1956–December 31, 1958, to provide a co-operative research organization for an industry with an estimated annual turnover of £35 million and employing some 12,000–13,000 operatives. A grant to the National Institute of Industrial Psychology on the same terms as those governing grants to research associations will make possible sustained studies of general interest, and the grant terms of the Commonwealth Mycological Institute have been modified for the final two years of the current grant period. A special grant was offered to the British Coke Research Association for the erection of a full-scale coke-oven plant, the first in Britain to be available for research.

New terms of grant were offered to eight research associations and research councils during the year. The Printing, Packaging and Allied Trades Research Association will receive for the period April 1, 1956–March 31, 1961, a block grant of £27,000 conditional on £67,500 coming from industry, with up to a further £18,000 on a cent-per-cent basis. A main research project has been an investigation into what constitutes a good print, so that a method of comparison can be evolved. A new damping solution which will minimize the printing of non-image areas without leading to other troubles, and a treatment for preventing damping rollers from rotting have been introduced for lithographers; further progress has been made with the development of a contact screen capable of giving improved tone reproduction in lithography, development work has continued on tests for assessing wear-resistance of book-binding materials, and accurate information is being accumulated on how packages behave in transit as a basis for improved design of containers.

The past year's work of the British Baking Industries Research Association, which, for the period July 1, 1956–June 30, 1957, will receive a block grant of £11,000, conditional on £20,000 coming from industry, with up to a further £8,000 on a cent-per-cent basis, reflects the influence of technological advances generally on a traditional industry. New techniques in mixing indicate changes in baking methods which may offer more economical production and products of improved quality, while deep freezing of bread, flour confectionery, doughs and batters also offers promising possibilities. Long-term experiments now completed indicate that no loss of vitamin B_1 occurs during the fermentation of bread dough; but in baking, 17·3–23·3 per cent of this vitamin is lost and, depending on the thickness of the slice of bread, a further 13·4–31·0 per cent is destroyed during toasting. One of the most important investigations of the British Jute Trade Research Association, the block grant of which has been increased to £16,000 a year for the period July 1, 1956–June 30, 1961, provided £27,000 is received from industry, with up to a further £10,000 on a cent-per-cent basis, is concerned with improving the quality of jute yarns as a result of changes in carding procedures. A special softening machine has been developed to provide different types of fireproof finishes on jute cloths using a process developed in the laboratories, and an investigation on minimizing fibre degradation under exposure to sea-water has been largely completed. Basic and fundamental research (about one-fifth of the total effort) has been devoted to elucidating the chemical structure of the jute fibre and the mechanism of chemical reactions which adversely affect fibre properties.

The Research Association of British Paint, Colour and Varnish Manufacturers will receive a block grant of £22,500 for the period July 1, 1956–June 30, 1961, conditional on £45,000 coming from industry and up to a further £12,000 on a cent-per-cent basis. Radioactive tracer techniques have proved of great value in studies of reaction mechanisms involved in processing drying oils and in the drying of films, while in work on epoxide resins infra-red spectroscopy has been used to follow the basic reactions during curing with amines and polyamides. Methods of assessing the particle-size, shape and distribution and total surface area of pigment powders are being made more effective and reliable, and the crystal structure of pigments has been further investigated; much has been learnt by direct observation of the position of pigment particles in paint films, singly or in clusters and at various depths. A study of spectrophotometric and potentiometric titration of chromate ions in acid solution has led to a method of determining chromates in pigments, and the effects of selected pigments have been closely examined in relation to

the build-up of films and their breakdown. For the period July 1, 1956–June 30, 1961, the British Rayon Research Association will receive a block grant of £80,000 a year, conditional on £250,000 being received from industry, with an additional £50 for each £100 contributed by industry up to a maximum of £10,000. In fundamental research considerable progress has been made in elucidating the precise molecular arrangements in the crystalline forms of cellulose, particularly by using infra-red spectroscopy, while a study of the kinetics of the photochemical breakdown of cellulose in the presence of dyestuffs has established that the activated triplet state of the dye molecule is responsible for the breakdown. The Association has undertaken a programme of work on blended yarns, and finds that there are no outstanding difficulties in spinning, warping and weaving in producing cloths from blends of viscose with acetate rayon, nylon, 'Terylene', 'Orlon', 'Celon' and 'Acrilan'. Application of fluid-bed techniques in textile processing operations, such as drying, dyeing and finishing, appears to offer great potential savings.

For the period April 1, 1956–March 31, 1958, the British Scientific Instrument Research Association will receive a block grant of £40,000 per annum provided that £25,000 is received from industry, with up to a further £15,000 on a cent-per-cent basis. Progress is being made in an important investigation of ceramic elements which are sensitive to humidity, and an improved amplifier has been devised for the millivolt-level. A method of calculating the transmission characteristics of multi-layer interference filters has been developed. The main work of the British Electrical and Allied Industries Research Association, which for the period January 1, 1957–December 31, 1958, will receive a block grant of £100,000 a year, conditional on £200,000 coming from industry, continues to be concerned with the generation of electrical energy, its economical transmission and distribution, its most efficient utilization and the reliability of equipment, and about 15 per cent of the effort continues to be of long-term fundamental character. The hydrogen–oxygen fuel cell is now ready for industrial development, and new ground has been broken in the study of the interruption of circuits *in vacuo*. There appear to be promising applications to high- and low-power switchgear, contactors and rectifiers. The use of digital computers has permitted the application of more accurate mathematical methods of calculating short-circuit forces in transformers; laboratory work continued on basic problems of crop drying and the design of farm-dryers has been improved. A study of the relation between moisture content and discharge inception in impregnated paper insulation has established a strong correlation between these properties, while the study of ferro-electric materials is now directed to mixed sodium/potassium niobates. The Wool Industries Research Association, which for the period October 1, 1956–September 30, 1958, will receive a block grant of £40,000 a year, conditional on £110,000 coming from industry, with up to a further £30,000 on a cent-per-cent basis, is putting into production a dropper pinning machine, which eliminates much labour in setting up the warp stop motion on automatic looms. The Raper autoleveller drawing system, in the development of which the Association assisted, has proved most successful, offering a 10 per cent saving in labour as well as significant reduction in waste. Work on piece scouring has shown how economies in the use of hot water as well as in scouring-time can be obtained while maintaining or improving the quality of the product, and a more detailed study of fibres containing radioactive cystine showed no differentiation between the ortho- and para-keratins which have been postulated for the two halves of the fibre.

Of the work of the remaining research associations, only a few points can be mentioned here to illustrate further the many-sided bearing of the Department's work on the national life of Britain. The British Boot, Shoe and Allied Trades Research Association has done much practical work on the difficult problems of securing suitable adhesion between the uppers of shoes and newer synthetic solings, and promising and original work has been done at an experimental training centre to develop methods of selecting and training untrained labour for stitching operations in shoe factories. The British Ceramic Research Association has designed a satisfactory hood for the control of dust from the towing process and for dealing with the allied problem of hollow-ware fettling, as well as studying the effect of rate of drying on strains set up in clay bricks and blocks and the magnitude of the stresses that cause cracking. The British Coal Utilization Research Association has constructed special apparatus, consisting of a model fuel-bed burning beneath an electrostatic precipitator, for measuring the smoking tendency of coals and of manufactured smokeless fuels. The Cutler Research Council has developed a process for bending curved scissor blades that has been almost universally adopted by that section of the trade.

Fundamental data on the nutritive value of the proteins of flour, obtained by the Research Association of British Flour-Millers, indicate that the potential value of wheat protein is only fully mobilized in the presence of relatively small amounts of other proteins which are good sources of lysine. When these conditions are realized, the protein of wheat assists notably in maintaining a high biological value for the mixed proteins in the diet; and, so far as the protein content is concerned, the rate of extraction of the flour then becomes unimportant. The British Food Manufacturing Industries Research Association has extended its study of the increase in 'mould count' of soft fruits during transport and its retardation under improved conditions of transport, and the Fruit and Vegetable Canning and Quick Freezing Research Association is again investigating the chemical and physical changes during the ripening of green peas for canning and freezing. By the use of trypsin digestion in measuring the average molecular weight of fractions of gelatin by the technique of light scattering, the British Gelatine and Glue Research Association has removed the principal uncertainty in this method, the gelatin being degraded in a few minutes to an extent which permits the direct measurement of scatter due to impurities. A major project of the British Glass Industry Research Association is to reach some understanding of the mechanical strength of glass; while the fundamental work of the British Hydromechanics Research Association on the flow of liquid–solid mixtures in pipes has been extended from the behaviour of relatively large particles—of particular interest in connexion with coal transport—to smaller sizes of material. The new continuous casting plant of the British Iron and Steel Research Association promises to give outputs of steel considerably higher than the

present 7 tons an hour. The new method of flame-proofing nylon net devised by the Lace Research Association is now being used on almost all nylon net placed on the market by the industry. The British Launderers' Research Association has found that 'Polythene' is suitable only for low-temperature washing, but that some 'Terylene' garments will stand processing of the type suitable for white cotton. A dominant feature of the work of the British Leather Manufacturers' Research Association has been the study of methods of producing leathers with specific properties, such as hard wear, water-proofness and flexibility. Investigations by the Motor Industry Research Association point to the possibility of virtually eliminating brake squeal at small cost, and the Association has also sponsored a study of the mechanism of oil consumption by the engine piston and rings. The non-destructive thickness gauge for metallic coatings invented in the British Non-Ferrous Metals Research Association's laboratories has now been developed to measure the thickness of duplex coatings, particularly nickel and copper coatings on steel and on zinc die-castings, while progress is reported in the production of thick uncracked chromium deposits, using conventional plating plant and procedure. Oil-less water-based cutting fluids containing non-proprietary corrosion inhibitors developed by the Production Engineering Research Association have offered important savings to manufacturers of such fluids, and work of the Research Association of British Rubber Manufacturers on the prevention of deterioration due to traces of copper, manganese and iron using sequestering agents has added greatly to our knowledge of these oxidation processes and how these trace metals and sequestering agents work.

SCIENCE IN SCHOOLS

A SESSION of Section X (Corresponding Societies) of the British Association for the Advancement of Science was held on September 10 in the Great Lecture Theatre of the Science Buildings of University College, Dublin. The audience, which was large, included Prof. P. M. S. Blackett, president of the Association, and Mrs. Blackett; Dr. Henry St. John Atkins, president of University College, Cork; The Rev. Prof. J. McConnell, of Maynooth; Dr. A. C. Williams, senior chief inspector of the Ministry of Education of Northern Ireland; Mr. P. McGeown, inspector of the Department of Education in Eire; Prof. J. Doyle, Prof. T. Murphy and Prof. F. Hackett, of University College, Dublin. Prof. D. A. Webb, of Trinity College, Dublin, president of Section X, was in the chair.

The Rev. Dr. M. T. Casey, lecturer in general science at Maynooth College and senior science master at Newbridge, opened the session with an address on "Science in Our Irish Schools". He said that only 60 per cent of the boys and less than 50 per cent of girls take an academic science subject at Leaving Certificate level. In girls' schools generally—with some very notable exceptions—academic science is much neglected. Very few take physics or chemistry. Some take botany, but the majority select physiology and hygiene as a kind of 'soft option'. In the absence of physics and chemistry, this subject loses a great deal of its value. All this is to be deplored, especially as there is no valid reason why girls should not reach a degree of proficiency in science comparable to that attained by boys.

The great difference between the attitude of Irish and British schools to science is to be explained by the difference in industrial conditions. Britain, heavily industrialized, is only with difficulty able to meet the demand for scientists, whereas in Ireland industry is not so insistent and the supply usually exceeds the demand. This has its repercussions in Irish schools, where the arts subjects tend to dominate the curriculum. Now, modern science, apart from its being a major force in world affairs, has a very definite and unique cultural value, for it discovers in an ever-increasing measure the beauty of form and function that abounds in Nature which itself is the handiwork of the Creator. If the study of the arts—the mere artefacts of man—is cultural, how much more so the study of Nature itself. Science has a very definite and irrefutable claim to be taught even for its own sake and in all schools, for it forms an essential part of a liberal education. A person who knows nothing about science must be regarded as only partially educated. In Ireland specialization at school level is not envisaged, hence it follows that the exclusive study of physics and chemistry as the only science subjects at this level is unsound in principle, since it narrows down the outlook of the young mind. Biology must form an integral part of every school science course. To neglect biology is to neglect at least one half of natural phenomena. In Ireland, where the basic industry is agriculture, the teaching of biology becomes a national necessity.

In Ireland there is a scarcity of science teachers owing to the absorption of science graduates by industry. This could be remedied by asking the teaching priests, nuns and brothers to take up science teaching in greater numbers.

The first of the juvenile lectures was given by Mr. John D. Gallivan, of the sixth form at Newbridge College. He read a very interesting paper, illustrated by lantern slides, on "The Reverend Dr. Callan of Maynooth, pioneer of electrical research". Callan was born in Co. Louth about 1799 and spent the greater part of his life in St. Patrick's College, Maynooth, where he held the chair of natural philosophy from 1826 until his death early in 1864. Attracted by the researches of Faraday and Sturgeon, he built a giant horse-shoe magnet, some 7 ft. high and weighing 210 lb. When supplied with current from his battery, this magnet could lift two hundred times its own weight. Before 1836, Callan had investigated the principle of the electric motor and had built three. In the earlier forms, he employed a wheel having horizontal soft-iron bars attached to its rim. This was made to rotate by an intermittently energized electromagnet placed under it, the interruptions of current being made by the rotating wheel. A later model using forty electromagnets was able "to

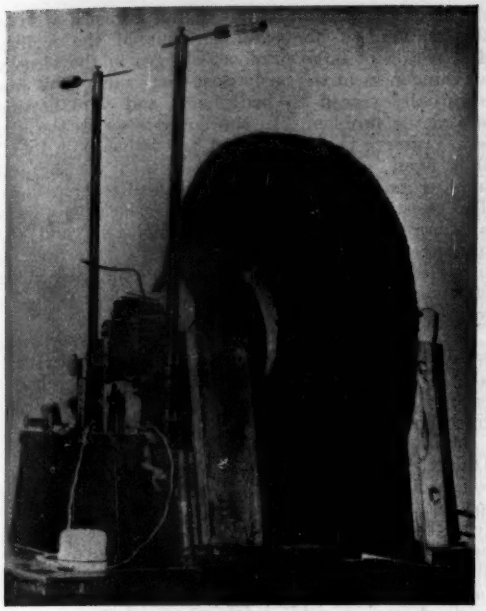

Fig. 1. Callan's medium-sized induction coil, now in the College Museum, Maynooth

propel at eight miles per hour, a thirteen hundredweight carriage". Callan also experimented with various types of primary cell and eventually arrived at one which was manufactured commercially by E. M. Clarke, of The Strand, London, and called the "Maynooth Battery". The positive plate was a cast-iron container, holding a porous pot with the zinc plate enclosed.

Callan's most important invention was the induction coil. When repeating some of Faraday's experiments on electromagnetic induction, Callan found that the shorter the interval at break, the higher the voltage of the induced current. From the escapement mechanism of an old clock, he constructed an interrupter which gave several thousand interruptions per minute. Using this apparatus coupled to his horse-shoe magnet on which he wound a secondary coil over the primary, he found that the machine would give prodigious shocks. He sent the whole apparatus to Sturgeon, who demonstrated it at the London Exhibition of 1837, where it attracted much attention. Callan now constructed his 'medium-sized' coil. This had a bundle of soft iron rods as core on which he wound the primary coil. Over this he wound a secondary coil of very fine wire very carefully insulated. The interrupter was of the trembler type devised by his contemporary, Prof. McGaulay, of Dublin. This apparatus gave very considerable sparks. Callan still continued and made his giant induction coil, which was built on the same principle as the medium one. The core is 42 in. long and the primary coil is made from copper wire, ¼ in. in diameter, insulated with thread and wound in three layers. The whole is enclosed in an insulating paste made from wax and gutta percha. The secondary consists of three coils each containing about ten miles of very fine iron wire all carefully insulated with his paste. Callan had a large condenser across the interrupter, and using three cells of his Maynooth battery to feed the primary coil, he got sparks 16 in. long from the secondary terminals.

For some time Callan's claim to the invention of the induction coil was in dispute, but it has long since been vindicated beyond all controversy. The principal evidence is to be found in Callan's own papers published in Sturgeon's *Annals of Electricity* (1, 493; September 11, 1837), where we have the first known reference to the modern induction coil, and also in the *Philosophical Magazine* (1836). Noad's "Treatise on Electricity" (1857) and Prof. J. A. Fleming's "The Alternate Current Transformer" also pay tribute to Callan as the inventor of the induction coil. Furthermore, French writers no longer claim Ruhmkorff (who constructed his first coil in 1851, fourteen years after Callan's) as its inventor. Mr. Gallivan concluded his paper by paying a tribute to Prof. McLaughlin, vice-president of Maynooth, whose researches had rescued Callan from oblivion.

Miss Valerie B. Poynton, of Alexandra College, Dublin, read a very interesting account of a year's practical work in the realm of marine zoology, entitled "Round Dublin in the Steps of a Marine Biologist". The undertaking of the actual work was inspired by the book "Life of the Shore and Shallow Sea", in which Douglas Wilson urges the would-be naturalist to see the inhabitants of the sea-shore in their natural surroundings. Miss Poynton agreed that while the preserved specimen had undoubted reference value, it could never replace the living animal. "The graceful undulating movement of the planktonic worm *Tomopteris*, as it flashes through the water, provides an unforgettable sight; while the symmetry and beauty of the delicate comb-jellies and the geometric precision with which they move their cilia can never be visualized by those who have not

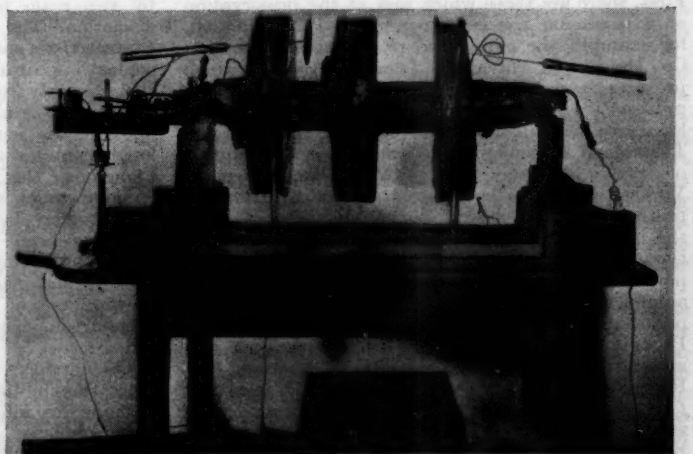

Fig. 2. Callan's 'giant' induction coil, now in the College Museum, Maynooth

had the good fortune to have seen those animals alive." Although the survey extended all around Dublin Bay from Malahide on the north side to Dalkey on the south, Dalkey Island itself formed the background of Miss Poynton's paper. The island has an area of 21 acres and is separated from the mainland by a narrow Sound. It is nine miles south of Dublin and owes its name to Danish invaders. 'Dalkey' comes from the Gaelic 'Deilginis', which means 'Thorn Island'. The area has granite for its underlying rock —it lies at the extreme tip of the Leinster granite chain—and Dalkey Sound may have been due to glaciation.

Methods of collecting and preserving material were described. Dredging was mentioned as the 'most exciting' method, since each new dredge held unlimited possibilities; there was always the chance that something new and long-sought might appear, while plankton-hauling could be described as most fascinating.

A short account was given of the environment of marine animals and of the hazards which they must overcome in order to survive and reproduce. Life in the rock pools differs from both life in the open sea and life under the boulders of the shore, so that the environment of the fauna in the immediate vicinity of Dalkey is quite complex. It is a series of environments rather than one well-defined habitat.

The commonest members of the fauna were discussed so vividly that the speaker seemed to communicate some of her enthusiasm to her audience. Her subjects ranged from the lowly sponges to the larger fishes and they were aptly illustrated by living specimens in aquaria on the bench. Very clearly, Miss Poynton's "year's work became something in the nature of a treasure hunt which was very well rewarded".

Mr. Jonathan R. Tinker, of the sixth form at Charterhouse, delivered a lively address on "Bird Reserves". He briefly discussed the various kinds of reserve, which ranged from small sanctuaries in private gardens to the great national reserves such as the Yellowstone National Park in the United States. As a result of the Wild Birds Protection Acts, special areas had been set aside in the wintering, feeding or nesting grounds of certain species. He classified these reserves as being fourfold in type. First, there are those which aim at the preservation of a particular species threatened with extinction, for example, the red-necked phalarope sanctuary in Co. Mayo, and Havergate Island in Suffolk which protects the unique avocet colony. Texel in Holland protects a large colony of spoonbills, and there is a large area set aside in Canada for the whooping crane. The second type of reserve protects a small number of species like the Humber Wild-fowl Refuge in Yorkshire with its large areas of mud-flats for the protection of wild geese. Within this type, too, are the islands off the Pembrokeshire coast. The third type comprises those large tracts known as national parks which are maintained for their plant and animal communities. Lastly, there are various city parks, such as Phoenix Park in Dublin and Regent's Park in London, where birds are treated as just another amenity to be enjoyed by visitors. In Regent's Park there are some extremely rare wild fowl, including the mandarin duck. An important study of the breeding habits of the tufted duck has been recently carried out in the London parks. These sanctuaries have been quite successful in increasing the stocks of rare birds, but many problems arise in this matter, as, for example, that of the nightly destruction of large numbers of eggs in the ternery at Dungeness in the early post-war years. This was eventually traced to hedgehogs, and wire netting solved the problem. In the larger reserves the aim is to preserve the community, and it has been found that even a slight interference with the natural habitat may have profound ecological repercussions. The question of access to bird sanctuaries is always a thorny one. Normally, ornithologists and the interested public should have access to the reserves provided their presence will not have any disturbing effects. If such effects are serious, then even the ornithologists should be excluded.

Mr. Tinker said that in shooting birds sportsmen were selfish, for the dead birds were no longer available to others. Bird-watchers, on the other hand, enjoyed themselves and left the birds to be enjoyed by others.

Miss Christabel Smyth, of Alexandra College, Dublin, read to the meeting an account of "A Geological Tour in the Neighbourhood of Dublin". The area covered by this study extends north and south from Dublin to Rathdrum in Co. Wicklow and east and west from the coast to Poolaphuca in the Blessington Lakes. It falls into two main divisions: (*a*) a highland area—the Leinster chain—and (*b*) a lowland area to the north of the Leinster chain including the extreme eastern limit of the central plain of Ireland.

The rocks of the region are nearly all sediments of the Lower Palæozoic period, while the igneous intrusion of granite is associated with the Caledonian movement in Ireland. The sedimentary rocks include the Cambrian Bray series, the Ordovician shales and schists lying to the east and west of the granite intrusion and aureole, and the Carboniferous limestone north of the Leinster chain. This stratum is rich in fossils, especially around Malahide. The igneous rocks of the Ordovician period include dykes and sills of andesite, lavas and ashes. The volcano which lay east of Lambay Island radiated out dykes which may be seen on Howth and on Bray. The Leinster chain is the longest granite intrusion in the British Isles.

It is noticeable that the relief has been influenced by two main factors, namely, the rock type and glaciation. The different rock types have caused the characteristic shapes of the mountains, as the typical conical appearance of the sugar loaf quartzites and the smoothly rounded profile of Djouce Mountain, which is a granite formation. Glaciation has left many of the usual features. The district of Glendalough contains a number of these, U-valleys being numerous, the Lugduff brook culminating in a hanging valley and Lough Nahanagan in the Glendasan valley being a well-formed corrie. Boulder clay has been deposited thickly in many places. Moraines in many of the valleys form quite prominent features and glacial lakes have also been formed, as in the case of the lakes at Glendalough and at Blessington. The lecture was illustrated by coloured slides.

These papers on such diverse subjects point to great possibilities. The enthusiasm of the young authors was infectious, and they were greeted with warm applause. The generous Press notices of the session should be of great help in the campaign for more science in the schools. Michael T. Casey

THE ABYSSAL CIRCULATION OF THE OCEAN

A SYMPOSIUM on "The Abyssal Circulation of the Ocean" was held at the General Assembly of the International Union of Geodesy and Geophysics in Toronto during September 5–6. So very little positive knowledge exists about the nature of the deep circulation that it is possible to maintain entirely different points of view. G. A. Riley (United States) reviewed the steady-state theory, proposed some thirty years ago by Merz, Defant and Wüst. This view appears to be partially confirmed by F. C. Fuglister's (United States) recent re-survey in *Crawford* of two original profiles across the South Atlantic by *Meteor* in 1925–27. As Fuglister showed, there is little observable change in either the temperature or salinity of the deep waters in the northern South Atlantic over the thirty-year interval (in the Deep Water of both eastern and western troughs there is a decrease of temperature of less than 0·04° C. and an increase of salinity of less than 0·04 per mille, and in the Bottom Water of the western trough an increase of both temperature and salinity of about 0·02° C. and 0·02 per mille). On the other hand, L. V. Worthington (United States) maintains, on the basis of what appears to be a general decrease of concentration of dissolved oxygen in the deep waters of the Atlantic between 50° N. and 16° S. since about 1925, that the deep water of the North Atlantic (below 2,000-m. depth) is now isolated from the surface and is no longer being renewed during the winter by sinking water masses off Greenland as is generally supposed. L. H. N. Cooper (United Kingdom) presented evidence that corrosion products in reversing water bottles may absorb oxygen from sea-water at a serious rate, and that with a new set of bottles, erratic variations in concentration of deep-water oxygen may occur near a continental slope. Thus Cooper holds that judgment may need to be suspended on Worthington's conclusions, based as they are on oxygen data. Riley believes that the North Atlantic deep waters have never been wholly depleted of oxygen in the geological past, so that it is unlikely that at present there can be very large fluctuations in oxygen content. It is difficult to reconcile this view with the quite firm indication to the contrary shown by Worthington's data.

The new hydrographic surveys of the North Atlantic by *Discovery II* and *Atlantis* were made using the new Schleicher–Bradshaw salinity bridge instead of the traditional salinity titration determination method. Thus a new high degree of resolution in the functional relation between salinity and temperature (the T–S relation) has been disclosed. The reason for such a relationship has always been completely obscure; however, N. P. Fofonoff's (Canada) new studies of the effect of the non-linearities of the equation of state of sea-water on the vertical stability and mixing appear to indicate ways in which this hitherto mysterious relationship may be explained.

One hopes that the new interest in the ocean on the part of the geochemists will result in many helpful geochemical studies of the distribution of rather esoteric properties of sea-water which may shed light on the problem of the circulation. In fact, it was suggested that it might be a good idea to try to organize, under international auspices, a world geochemical expedition to explore the entire world-ocean, and to procure a special ship and other necessary equipment. W. C. Broecker and his collaborators (United States) presented recent measurements of carbon-14 made at the Lamont Geological Observatory from water samples at a number of positions in the North Atlantic Ocean, indicating a mean residence-time of 650 years for deep water in the North Atlantic and also a rather large lateral mixing sufficient to produce near-homogeneity of carbon-14 over the deep North Atlantic. F. Koczy (United States) estimated values of the vertical eddy diffusivity from measurements of the vertical distribution of radium over the deep ocean floor. The use and implications of the distributions of particle content as an indicator of water mass were described by N. G. Jerlov (Sweden), and of the ratio of oxygen-18 to oxygen-16 as an indicator of source of water by B. Benson (United States). A. C. Redfield (United States) described the relation of the phosphorus content of the world-ocean to its general circulation, and presented a chart of the distribution of phosphates at 2,000-m. depth over the world-ocean.

H. Mosby (Norway) and J. Eggvin (Norway) described conditions in the Norwegian Sea, and G. Dietrich (Germany) the occasional floods of Norwegian Sea water which spill over the submarine ridges separating the Norwegian Sea from the rest of the Atlantic. L. V. Worthington pointed out that the view that these overpourings can contribute directly to the formation to-day of North Atlantic deep water seems doubtful on the basis of the new section along 50° N. made by *Discovery II*. On the other hand, there is direct observational evidence of a rather vigorous circulation in the deep water (J. C. Swallow and L. V. Worthington, *Nature*, **179**, 1183; 1957) as a result of the measurements of the deep western boundary current under the Gulf Stream made by *Discovery II* and *Atlantis* last Spring; and G. Wüst's (Germany) new computations show high rates of transport in the deep water of the South Atlantic as well.

A map discussion centred about the preparation of a chart of temperature, salinity and dissolved oxygen content at 4,000-m. depth, constructed by E. D. Stroup (United States), and rough working copies were distributed to all participants. This chart contains all the deep data yet published and it is hoped that it will prove helpful to those planning future oceanographic surveys. A chart of temperature, salinity and oxygen content of the Pacific at the 5,000-m. level was presented by W. Wooster and G. Volkmann (United States).

The general picture emerging from these various descriptive studies is that the general flow of water below 2,000-m. depth in the ocean is directed from quite limited areas in the northern North Atlantic and from the shallow shelf areas surrounding Antarctica into the Indian and Pacific Oceans. The regions where water is supplied by sinking to the level beneath 2,000 m. are doubtless quite small, and probably

intermittent. On the other hand, the upward flow of water out of the deep ocean evidently occurs in a very widespread manner all over the ocean, and it is presumably this upward flow which prevents the hot water at the surface from gradually working down into the deep water (even at the tropics the warm surface layers are relatively shallow and the temperature of bottom waters is less than 3° C.). The average time of residence of a particle of water between its introduction into the deep water at a source and its eventual upwelling through the 2,000-m. level is estimated at between 400 and 1,200 years. Superposed upon this mean circulation there are evidently rather major perturbations.

A theoretical method for constructing the horizontal field of flow in the abyss was described by H. Stommel (United States), and some experimental studies in a rotating basin, designed to test partially these theoretical ideas, were presented by A. Faller (United States). Unfortunately the three theoretical oceanographers from the U.S.S.R. who were invited to attend the symposium (W. B. Stockmann, P. S. Lineykin and M. Koshljakov) were unable to come to Toronto, but the official delegate, V. G. Kort, kindly read a short abstract of a paper by M. Koshljakov, who is of the opinion that the abyssal circulation is essentially produced by wind, that lateral eddy viscosity is of vital importance, and that the deep flows are almost always in the same direction as surface currents. These views are quite the opposite of those expressed by Stommel, who regards the deep circulation as an essentially heat-driven and salt-driven engine, and viscosity as insignificant dynamically. In general, Stommel considers that the surface flows and deep flows are in opposite directions, except in a few instances where the wind-driven surface layers are forced to flow otherwise. This theory predicts that in the deep water the mean meridional components of velocity are everywhere directed poleward except in the western boundary streams which connect the slow central flow to regions of formation of deep water. It is thus possible to predict the deep counter-currents under the Gulf Stream. Similarly, we can now expect to find a very narrow intense northward current between 3,000 and 5,000 m. over the Tonga–Kermadec Trench, which feeds the entire Pacific with deep water. One hopes that the adherents of these two rival theories of abyssal circulation will be able to develop them quantitatively and in sufficient detail so that future direct measurements, such as those using Swallow's neutrally buoyant floats, will effect a clear-cut decision in favour of one or the other. It is in this way that science progresses.

R. B. Montgomery, M. Pollak and J. Cochrane (United States) presented a temperature–salinity diagram showing the frequency of occurrence of waters of various temperatures and salinities in each of the major oceans separately, and combined as a world-ocean. Two other theoretical papers, not specifically related to the topic of deep circulation, were read at the Symposium : a study of the formation of multiple currents in flow in a divergent channel under the influence of rotation (B. Saint-Guily, France) and a method for computing actual currents from the geostrophically computed currents in the presence of uniform vertical eddy viscosity (K. Hidaka, Japan). Papers by M. Uda (Japan), K. Yoshida (Japan) and A. E. Maxwell (United States) were read in title only.

H. Stommel

NEWS and VIEWS

The Artificial Earth Satellite

The successful launching of an artificial Earth satellite ranks as a technical achievement of the first magnitude and an event of great scientific interest. From the early observations on the 20 Mc./s. and 40 Mc./s. signals transmitted by the satellite, the orbit appears to be at a mean altitude of 350 miles with a mean speed of about 24,800 ft./sec. The orbit is slightly elliptical, in a plane inclined at about 65° to the equator. It is to be expected that, as a result of the Earth's oblateness, the orbital plane will rotate slowly about the Earth's axis at about $2\frac{1}{2}$° a day, and in a direction opposite to the Earth's rotation. The major axis of the orbital ellipse will also regress backwards, relative to orbital direction, at less than $\frac{1}{4}$° per day. It is to be hoped that the radio-interferometer observations, coupled with the theoretical orbital data just quoted, will allow the computation of sufficiently accurate orbits to facilitate further accurate observations by optical means.

At the time of writing, it is difficult to forecast the total life-time of the satellite since the density of the atmosphere is known only very imprecisely at heights of 250 miles and higher. Assuming a value of 10^{-11} times the density at sea-level, one may estimate that a satellite with perigee at 250 miles should survive for about a month. Although theoretical computations of aerodynamic drag, heat protection and heat-sink characteristics suggest that safe re-entry to the Earth's atmosphere should be feasible, recovery of an intact satellite and its instruments is likely to prove a formidable technological problem. The warm congratulations of all those engaged in the applied science of aeronautics and rocket propulsion must go to the Soviet scientists and engineers involved in the satellite project. Future satellite launchings are awaited with the utmost interest.

Paul Instrument Fund Awards

Awards of grants by the Paul Instrument Fund Committee have been made as follows : £2,700 to Prof. G. F. J. Garlick, professor of physics in the University of Hull, to enable him to carry out studies of phosphors and photoconductors with the view of the development of solid state light image amplifiers or converters ; £2,000 to Dr. H. H. Hopkins, senior lecturer in physics (technical optics), Imperial College of Science and Technology, London, for continuation of the construction of a static scanning fibrescope, the aim of which is to provide a flexible unit capable of transporting optical images along its length ; £100 to Dr. D. Gabor, Mullard reader in electronics, Imperial College of Science and Technology, making

a total grant of £1,900 for work on a new type of Wilson cloud chamber in the form of a resonant microwave cavity in which time marks are applied to the particle tracks at equal intervals (see p. 746 of this issue of *Nature*). The Paul Instrument Fund Committee, composed of representatives of the Royal Society, the Physical Society, the Institute of Physics and the Institution of Electrical Engineers, was set up in 1945 "to receive applications from British subjects who are research workers in Great Britain for grants for the design, construction and maintenance of novel, unusual or much improved types of physical instruments and apparatus for investigations in pure or applied physical science".

Rockefeller Institute Quarterly

THE Rockefeller Institute for Medical Research is now issuing, primarily for present and former members of the Institute, the *Rockefeller Institute Quarterly*, the first issue being dated March 1957. It is intended to provide background information of the current work of the Institute and its plans for future development. The first issue contains a brief account of the research programme of the Population Council, the Medical Division and Laboratory of which have been housed at the Institute since September 1954. The Laboratory also assists in the diagnosis of reproductive defects in men by examining testicular biopsies and has developed a technique for determining genetic sex by examining somatic cells such as those in the skin or on oral smears. There is also a Demographic Division which seeks to promote the scientific study of population problems. The Abby Aldrich Rockefeller Hall, which is nearing completion, is to provide a social and residential centre for visiting scientists from all over the world and for the Institute faculty. Extensive changes in the facilities of the Institute buildings, which are nearing completion, will provide for Dr. F. Lipmann's biochemistry laboratory and laboratories for Dr. E. L. Tatum's work on the biochemical genetics of micro-organisms. There are also notes on the Institute's joint programme with the National Academy of Sciences and National Research Council to assist Hungarian scholars, and on the establishment of the post of Administrative Associate for Information Services, as well as lists of appointments and distinctions.

Information Service on Psychopharmacology

A CLEARING house of information on psychopharmacology is being established by the Psychopharmacology Service Center of the U.S. National Institute of Mental Health. An extensive collection of the literature in this field, including pharmacological, clinical, behavioural and experimental studies of the ataraxic, psychotomimetic and other centrally acting drugs, will be classified and coded to enable the staff to answer a wide variety of technical and scientific questions. As soon as enough materials have been assembled, the Center plans to offer bibliographical and reference services as well as the preparation of critical and analytical reviews of special topics in the field. In order to accelerate the growth of the literature collection, the Center invites persons working in the field to provide three copies of any papers that deal with their work—whether reprints, pre-publication manuscripts, progress reports, informal mimeographed reports, papers read at meetings, or abstracts. Letters outlining work in progress would also be welcome. Any restrictions that authors may wish to place on the Center's use of their papers will be strictly observed. All materials should be addressed to the Technical Information Unit, Psychopharmacology Service Center, National Institute of Mental Health, 8719 Colesville Road, Silver Spring, Maryland.

Search for and use of Natural Resources

Impact of March 1957 contains an article by J. Gray, "Technology and the Quest for Materials", which is a timely corrective to the common tendency to over-simplify the issues in controversy on population and resources and the implication of technical changes. Mr. Gray emphasizes the need to plan research ahead rather than continue to rely on the haphazard reactions of private enterprise, but he points out that while all the available evidence suggests that the demand for materials will continue to rise sharply in the next few decades, the urgency of this need is still debatable. The great increase in the consumption of leading metals since 1880 is due to the industrialization of a handful of countries: nine-tenths or more of the world's pig iron, copper, lead, zinc and tin, outside the Communist countries, are consumed in Europe, the United States, Canada, New Zealand, Australia and Japan, but it is probable that the under-developed countries will only slowly affect world demand. To keep production per head of population at the present level, however, requires an increase of nearly 3 per cent per annum in Latin America, 2 per cent in Asia and Africa, and at least 1·5 per cent in North America, Australasia and the U.S.S.R. Mr. Gray suggests that among the problems which most need examination in this context, regardless of cost or immediate return, are substitutes for coal and base metals, the use of alloying metals, new sources of plastics, new fuels for road and air transport and the scope for little-used materials. As regards conservation of resources, the two most obvious steps are to inspire and stimulate interest in design, and the systematic use of scrap. More serious is the need for research on methods of ore dressing and extraction, but while there is room for more conscious planning of prospecting, there are difficulties both on the national and the international plane, chiefly financial and nationalistic. The main hope of increasing the supply of agricultural raw materials lies in increasing the yield per acre.

Information and Communication

A PAPER by Dr. H. Coblans on "New Methods and Techniques for the Communication of Knowledge" in the *Unesco Bulletin for Libraries* of July (Paris: Unesco) is a first step in a long-term programme of study, experiment and development in a field which is becoming a principal interest of Unesco. Starting from discussions and conclusions reached at the Royal Society Scientific Information Conference, the Unesco International Conference on Science Abstracting and the Unesco Conference on the Improvement of Bibliographical Services, Dr. Coblans considers first the new techniques and particularly their use by the Gmelin-Institut für anorganische Chemie, the Centre National de la Recherche Scientifique (Paris) and the Chemical-Biological Centre, Washington; he then suggests that costing studies for definite subject-fields on an operational basis should be stimulated in the major countries in which mechanical selectors

are available. Unesco should commission a critical study of the potentialities of the apparatus described in the Federation of International Documentation Manual, indicating its value and limitations for the main uses in libraries and documentation work. He also recommends the issue of international lists of translations of periodical articles, using the best available mechanical techniques, the establishment in each country or suitable region of at least one punched-card unit with photo-offset equipment for the production of the lists and indexes as needed, and the compilation of a manual of the practice and organization of such services, as well as the subsidizing of research on the production of equipment more suited for the production of these lists. Unesco should also organize an international conference of experts from all patent offices to discuss mechanization, and publish in its proceedings an authoritative summary of the state of present knowledge in this field. In collaboration with the International Federations in Bibliography, Pure and Applied Sciences and Social Sciences, Unesco should also establish and maintain the administrative procedures required to link national and international services in the field of communication of knowledge.

With regard to the older techniques, Dr. Coblans suggests that international organizations should arrange to send their documents to the relevant abstracting periodicals, that in each country there should be one overall social science centre to receive lists of specialists, research in progress and information about conferences and the location of unpublished material, and that the Unesco Social Science Clearing House should co-ordinate the activities of all such centres. He also advocates a long-term study of the adequacy of the scientific periodical as a method of communication, a survey, with the help of the Abstracting Board of the International Council of Scientific Unions, of the extent to which the major abstracting and indexing services in the natural sciences cover articles in annual reviews and technical research reports, the issue of regular lists of published proceedings of international conferences, and a conference on the production and distribution of literature on nuclear energy.

Writing and Searching

Two recent articles in *Research* merit the close attention of every postgraduate research student and young research worker. The first, entitled "A Note on the Writing of Scientific Papers and Theses" (10, 168; May 1957), contains the substance of a lecture delivered at the Atomic Energy Research Establishment, Harwell, by Dr. W. Hume-Rothery. Though it is usual to give constant supervision during the course of a student's research work, very rarely is training given in the important task of writing and preparation of the subsequent report for publication. It is only too well known how poor is the presentation of many contributions to scientific journals. In his advice, Dr. Hume-Rothery adheres to traditional lines. He gives several examples to illustrate the more common faults, emphasizes the importance of conciseness and discusses how to make a paper interesting and clear. It is recommended that experimental results should be so displayed that the reader may see their general nature and, in addition, the exact values to within the limits of experimental accuracy. In this regard Dr. Hume-Rothery deplores the regulations of some journals against the showing of results in both tabular and diagrammatic form.

The second article, "Searching the Literature", by M. A. Short (10, 313; August 1957), although concerned specifically with the literature of physical and inorganic chemistry, nevertheless contains much of value to all chemists and physicists. In making the survey of the relevant literature before a research project is undertaken, there are two conflicting factors—speed and thoroughness—and some balance has to be struck between them. Dr. Short provides an excellent working guide for the ordinary research worker on how best to go about his search systematically. The main chemical and physical libraries in London; the various abstracting journals and their coverage; and the foreign periodicals which are available in an English translation are listed, and in appendixes details are given of suggested treatises and handbooks to be consulted and the titles of the journals of major importance published in the years prior to 1875. In conclusion, Dr. Short gives some brief but interesting advice about how to keep up to date, and how to record the information obtained from the search in an easily available form.

National Institute of Agricultural Botany

The report of the Council of the National Institute of Agricultural Botany for the year 1956 has now been published (The Secretary, N.I.A.B., Huntingdon Road, Cambridge. 2*s*.). During the year under review there was some reorganization of the work, and a new section, the Multiplication Branch, is now responsible for the increase of pure stocks of seed bred by the official plant breeding institutes. These include cereals and sugar beet from the Cambridge Plant Breeding Institute, grasses and clovers from the Welsh Plant Breeding Station, brassicas and onions from the National Vegetable Research Station, and hybrid tomatoes from the John Innes Horticultural Institution. The remainder of the Crop Improvement Branch is now more appropriately named the Trials Branch. Some 331 acres of stock seed crops of the Aberystwyth strains of grasses and clovers were harvested by the new Multiplication Branch and a further 640 acres by the Welsh Plant Breeding Station, the newly erected herbage granary coming into use for the first time. Interim comments on forty-five cereal varieties which have been tested for two or three years are reported by the Trials Branch and an account given of its work on vegetable crops, which has included group classifications of named seed stocks of brussels sprouts and carrots. Further expansion is reported by the Seed Production Branch. 63,000 acres of seed crops were approved under the cereal field approval scheme, while under that for herbage and seed certification, 90 per cent of all eligible crops of Aberystwyth strains of grasses and clovers were entered for the national comprehensive certification scheme in the first year of its operation. The total number of samples received by the Official Seed Testing Station was very similar to that of the previous year, the good harvesting conditions of 1955 being reflected in the high proportion of clover samples sent in.

Transference of Rust-resistance to Bread Wheats

It is known that some species in the genera *Agropyron* and *Aegilops* are highly resistant to the rusts which attack wheat. One way of making

practical use of this novel source of resistance is to transfer chromosome segments containing genes for resistance from the wild species to wheat by the translocation of small chromosome segments using X-radiation. Sears (Brookhaven Symposia in Biology, No. 9, 1956) succeeded in transferring resistance to leaf rust from *Aegilops umbellata* to wheat, and Elliott (*J. Hered.*, **48**, 77; 1957) has now accomplished the transference of resistance to the black rust of wheat from *Agropyron elongatum* (tall wheat grass) to the common bread wheat. Tall wheat grass is a $7x$ (heptaploid) species. The first step was to cross it with $6x$ (hexaploid) wheat. After a few segregating generations, stem resistance was stabilized at the octaploid level. A resistant octaploid was then pollinated by a susceptible wheat, and the hybrid seeds were irradiated in various ways. A single rust-resistant wheat-like plant, which was shown to be hexaploid and easily crossed with ordinary wheat, was isolated from the second generation after X-irradiation with a dosage of 18,000 r. units. All the sister plants were susceptible except for two weak, sterile grass-like plants. The resistant plant bred true to resistance in the next and subsequent generations. Cytological examination of crosses between the resistant form and a susceptible hexaploid wheat indicated that at least three chromosomal interchanges were involved, and that the presumed translocations were small and probably intercalary. This material cannot, as it stands, serve as a new commercial variety, since it falls short of the desired standards for milling and baking quality. The important thing about it is that it demonstrates a new method of combating a series of pathogens which are a menace to an essential food crop.

Meteor Orbits and Rainfall

E. G. Bowen has a paper on "A Prediction of a Meteor Orbital Period" in *The Observatory* (**77**, 898; 1957), in which he suggests that meteoritic dust has a nucleating effect which leads to heavy precipitation approximately thirty days after the dust enters the top of the atmosphere. Although the majority of meteorologists have opposed this hypothesis, contending that the results are a chance phenomenon and also that there are no physical grounds for expecting a connexion between meteor showers and rainfall, Bowen emphasizes that if the hypothesis is correct there exists in the meteorological records an impressive collection of information from which, in certain cases, a considerable amount of evidence about past meteor activity might be derived. Bowen refers to a paper of his in *J. Met.*, **13**, 142 (1956), which shows that if the daily rainfall of the first five weeks of the year is totalled for about 250 stations in different parts of the world over a period of fifty to sixty years, it does not result in a smooth curve but exhibits distinct peaks on January 12 and 22 and February 1. As is well known, these dates are about thirty days later than the Geminid, Ursid and Quadrantid meteor showers, respectively. While the records from which the curve was compiled included a fair sample of data from the northern hemisphere, the same did not apply to the southern hemisphere; but many more data from the latter have now become available, the samples coming from fifty stations in Australia, fifty in New Zealand, ten in South Africa and ten in the Argentine. From the data from these stations another curve has been drawn and it shows peaks which closely correspond on practically the same dates with those in the previous curve. It is admitted that a sharp difference of opinion exists among meteorologists regarding these peaks, the majority maintaining that a rainfall curve of this type is a smooth horizontal line with chance fluctuations about the mean, but Bowen contends that they have a real significance (see also *Nature*, **177**, 1121; 1956).

Plastic Mounts for Biological Display

In the issue of the *Museums Journal* for September, Dr. Blodwen Lloyd, of the Royal College of Science and Technology, Glasgow, describes a method of mounting biological specimens in transparent plastic. This entails sandwiching the specimens between two sheets of plastic, the air being driven out by the application of low heat and pressure. The technique is specially applicable to objects which are virtually two-dimensional, such as herbarium plants, but can also be used for the mounting of specimens in low relief, as, for example, small bones and woody twigs.

The Oliver Bird Trust

In July 1957 a charitable fund was established with the title of the Oliver Bird Trust, the Trustees being Mrs. M. A. Pyke, the Hon. Mrs. Burrell and Dr. A. S. Parkes. The Trust has as its object the advancement of knowledge of methods of fertility control with special reference to the promotion and provision of facilities for tests, clinical trials of systemic methods of contraception as they become available, and in the meantime the improvement of locally-acting spermicides. The Trustees will offer for award in each of the next five years a prize of not less than £250 and an Oliver Bird Medal for laboratory or clinical work bearing on the control of conception. The first prize will be offered early in 1958, and application should be made not later than December 31. They will also arrange two annual Oliver Bird Lectures: one with the aim of promoting in medical and scientific circles recognition of the importance of investigating fertility control; the other to be sponsored by the Society for the Study of Fertility, dealing with the technical aspects of the problem. The first technical lecture will be given on November 6 in the lecture theatre at University Hospital Medical School at 5 p.m. by Dr. T. Mann on "The Biochemical Basis of Spermicidal Activity". Finally the Trustees will set up a Council for the Investigation of Fertility Control, which will work in conjunction with the Family Planning Association and will be responsible for organizing tests and clinical trials. Further information can be obtained from the office of the Trust at 64 Sloane Street, London, S.W.1.

Advisory Group for Aeronautical Research and Development

The seventh general assembly of the Advisory Group for Aeronautical Research and Development of the North Atlantic Treaty Organization will be held on November 25–26 in Washington, D.C. Dr. Theodore von Kármán, chairman of the Advisory Group, will preside over the formal opening of the general assembly at the Shoreham Hotel, Washington, at which Gen. Nathan F. Twining, chairman of the Joint Chiefs of Staff, North Atlantic Treaty Organization, will give an address on the development of air power in the United States. The first session will be devoted

to a discussion on the general theme "Towards Higher Altitude", with Dr. Hugh L. Dryden, director of the National Advisory Committee for Aeronautics, in the chair. Introductory talks followed by general discussion will be given on: "Aerodynamics of Low Density Media" by Prof. G. N. Patterson, director, Institute of Aerophysics, University of Toronto; "Propulsion at High Altitudes", by M. F. Florio, technical director, Société d'Etudes pour la Propulsion par Réaction, and Messrs. M. Barrère and R. Siestrunck, Office National d'Etudes et de Recherches Aéronautiques; "Physics of the Stratosphere and Ionosphere", by Prof F. Dieminger, Max-Planck Institute; "High Altitude Flight Testing", by Major I. C. Kincheloe, jun., and H. M. Drake; "Aeromedical Problems of Flight above the Atmosphere", by Col. P. A. Campbell, Air Research and Development, United States Air Force. Reports on the activities of the Advisory Group will be given by the Panel Chairmen and the Director on the morning of November 26.

University News: Birmingham

The following appointments have recently been made in the University of Birmingham: L. Castillejo, to be lecturer in mathematical physics; Dr. G. C. Brock, to be lecturer in civil engineering; Dr. R. J. Allwood, to be temporary lecturer in civil engineering; G. V. Jeffreys and Dr. D. R. Oliver, to be lecturers in chemical engineering; R. W. Snell, to be lecturer in petroleum production engineering; P. D. Allen, to be lecturer in mechanical engineering; and Dr. B. Shaw, to be lecturer in medical biochemistry and pharmacology.

Dr. A. P. Batson, N. E. Booth and Dr. J. D. Hobson have been appointed Imperial Chemical Industries Research Fellows.

Announcements

Prof. Ragnar Granit, of the Medical Nobel Institute, Stockholm, has been awarded the Retzius Gold Medal of the Swedish Society of Physicians. Since 1897 this Medal has been awarded every tenth year, alternately in anatomy and physiology.

The Executive Council of the Commonwealth Agricultural Bureaux has elected Mr. T. Swaminathan, representing India, as chairman, in succession to Mr. C. E. Lambert, who represented the Colonial Territories. Dr. J. G. Malloch, representing Canada, has succeeded Mr. Swaminathan as vice-chairman.

Mr. L. Gosland has been appointed research manager of the Electrical Research Association and Mr. E. E. Hutchings head of the Member Relations Department. Mr. A. M. Cassie and Dr. L. H. Orton will be joint heads of the Switchgear Department, and Dr. G. Mole and Dr. F. Busemann head and deputy head, respectively, of the Transmission and Utilization Department.

Mr. D. R. Barber, formerly assistant to the director of the Norman Lockyer Observatory of the University of Exeter, has been appointed superintendent of the Observatory. Mr. D. L. Edwards, director of the Observatory since 1936, died in September 1956 (see *Nature*, 178, 1028; 1956).

The International Union against Cancer is to award a limited number of travel grants to enable young scientists who do not yet hold senior appointments, but who have already made significant contributions to research on cancer, to attend the 7th International Cancer Congress to be held in London during July 6–12, 1958. Application forms may be obtained from Dr. I. Berenblum, Weizmann Institute of Science, Rehovoth, Israel, to whom all inquiries should be addressed.

Applications are invited for the Helen Putnam Fellowship for Advanced Research, a postdoctoral resident fellowship for women, with research facilities at Harvard University. The research may be in any field related to genetics or mental health, including psychology, child development and other fields of social science. The stipend will be 3,500 dollars a year, with possibility of renewal. Application forms may be obtained from the Secretary of the Graduate School, Radcliffe College, Cambridge 38, Massachusetts. Completed applications should be returned not later than January 15, 1958. Announcement of the award will be made on or before February 15, 1958.

A new scholarship—the Frank Wright Scholarship—which will give the recipient the opportunity for further study in the United States at either the Textile Research Institute, Princeton, or at the Massachusetts Institute of Technology, is to be awarded by the Textile Institute. Candidates must have been born in the United Kingdom and must possess a university degree of sufficient standing for attendance at one of the two American institutions. The recipient of the scholarship will become a candidate there for the Ph.D. degree in chemistry, chemical engineering or mechanical engineering. The duration of the course will probably not exceed three and a half years, and the Fellow will be paid 1,500 dollars in each of the first two years plus 600 dollars tuition fees and 1,800 plus 600 dollars in the third year. The scholarship holder will be expected to give an undertaking to return to the United Kingdom at the conclusion of his course and to work there for a period of at least five years. Further information can be obtained from the General Secretary of the Textile Institute and applications must be returned not later than October 31.

Three scholarships in engineering, of about £450 a year according to circumstances and tenable in the Department of Engineering in the University of Southampton, are to be offered annually by Hoover Ltd. The scheme combines an honours degree course in mechanical and electrical engineering with complementary practical training in production engineering, research and development at the Hoover factory at Perivale. The training tasks are designed to be of a broad engineering nature, characteristic of processes carried out in industry generally in these fields. Training is further diversified by attachments to other factories in Britain and overseas. The student is under no obligation to Hoover Ltd. after graduation, nor is the company obliged to employ the graduate, but it is hoped that a suitable appointment may be available for successful honours candidates. Selection is by an examination, set by the University of Southampton, which is to be held at Hoover Ltd., Perivale, in February of each year. Details of the syllabus may be obtained from the University. Applications, which must be received before December 8, should be addressed to the Education and Training Officer, Hoover Ltd., Perivale, Greenford, Middlesex, from whom further information can be obtained.

LINNAEAN ANNIVERSARY CELEBRATIONS

By Dr. J. RAMSBOTTOM

As was to be expected, the Swedish celebrations of the 250th anniversary of the birth of Linnaeus were befitting to the memory of a world-famous scientist, and a national hero. A new statue —a copy of the one at Stockholm—was set up at Upsala, a medal was struck, telegraph forms bore a fine coloured representation of *Linnaea borealis*, special postage stamps were issued, and numerous works both by and on Linnaeus were displayed in the book-shops.

The celebrations proper began at his birthplace, Råshult, on May 23 (O.S. May 11), his birthday, and May 24, long regarded as such by, for example, the Linnean Society of London, owing to confusion when the Swedish calendar was changed. The University of Upsala, where Linnaeus was professor of medicine and botany (1741–78) and three times rector magnificus, as well as paying special tribute in the end-of-term ceremonies, arranged a symposium on "Systematics of To-day" (May 28–30), which was attended by about thirty foreign guests.

Those attending were welcomed at an opening ceremony in what was formerly the orangery of the old University Botanic Garden by the Rector Magnificus of the University of Upsala and by the Chancellor of the Swedish Universities, in short speeches. Then the president of the symposium, Prof. J. A. Nannfeldt, gave a brief address in which he spoke of Linnaeus's attitude to Nature, his concept of species and the appropriateness of the meeting as part of the Upsala celebrations. Afterwards a walk was taken round the Garden, again arranged as by Linnaeus, and a short visit to the adjoining professor's house, now used as a Linnaean museum. The attractive large yellow-flowered *Corydalis nobilis* was growing abundantly as a weed in the garden, as elsewhere in Upsala: it was introduced among seeds of *Dicentra spectabilis* sent to Linnaeus from Siberia.

The symposium proper was held at the University. Probably most people doubted whether a programme of twenty-seven papers, with discussions, could be crammed into four sessions. Each speaker had been allotted fifteen minutes, and all loyally kept to this, occasionally reminded of the passage of time by a sort of traffic-signal system in full view of the audience, with an accompanying buzz—an international self-denying ordinance with consequent smooth running, and general satisfaction: the improbable had been achieved. The opening paper was by E. Mayr (United States) on "The Evolutionary Significance of the Systematic Categories". The primary object of systematics has always been to permit grouping of the bewildering number of natural entities into collective units—to make order out of chaos. This seemingly purely practical task can be carried out in different ways depending on the basic philosophy adopted. Though the practical aims of taxonomists are still the same as in the time of Linnaeus, the underlying philosophy has changed drastically. There are two essential reasons for this: (1) the acceptance of the theory of evolution and, far more important, (2) the replacement of typological thinking by populations thinking. These are by no means two aspects of the same concept.

A species is a group of interbreeding populations. Individuals of which a species is composed are the visible expression and temporary containers of the 'gene pool' of the species. This pool is sharply limited to genes which can harmoniously combine into genotypes and produce successful phenotypes. Harmonious gene pools require protection against outside disturbance—the so-called isolating mechanisms. The limitation of the gene pool sharply restricts the ecological potentialities of a species. By reason of its limited genetic endowment each species is specialized to a greater or lesser degree: every new gene pool, every incipient new species, and every new species is an ecological experiment; a possibility of entering a new adaptive zone. This is the great evolutionary significance of the species.

There is a certain collective advantage in the stability of phenotypes. There is a 'developmental homœostasis' which permits of a great deal of genetic reconstruction without major morphological reconstruction. Once a successful phenotype has been evolved there will be an evolutionary tendency to preserve it. There is an optimum phenotype for a particular ecological niche.

Each morphological type is the produce of a long process of adaptation for a specific environment, namely, that occupied by the given taxonomic category. Each taxon is thus not only a morphological phenomenon or a genetic phenomenon, but also an ecological phenomenon. The re-organization of the gene complex which such an evolutionary adaptability entails cannot be reversed.

Julian S. Huxley (Great Britain) spoke on "Grades as an Auxiliary Method in Taxonomy". The aim of most post-Darwinian taxonomy has been to express natural (phyletic) relationships: the taxonomic units (genus, order, class, etc.) are assumed to denote monophyletic groups. Often, however, such groups have turned out to be certainly, or probably, di- or poly-phyletic (for example, Subholostei, Gryphaea). They should, therefore, be called grades, not monophyletic units.

Further, the co-existence, in all evolutionary processes, of improvement (anagenesis) as well as diversification by splitting (cladogenesis) necessitates the erection of a two-way taxonomic system, classifying assemblages by anagenetic *grades* as well as by cladogenetic monophyletic groups, for which the general term *clades* may be suggested.

In point of fact most taxonomic units have been recognized as such because they represent persistent grades of organization, while phylogeny is more speculative and is, for the most part, a matter not of observation but of deduction. In any event, anagenetic units (grades) are just as 'natural' or readily delimitable as monophyletic units (clades). Indeed, many taxa are simultaneously both grades and clades (for example, Amniota, Monotremata, *Dipneumonina*, *Equus*). Others, however, are only (polyphyletic) grades (for example, Metozoa, Teleostei, and various

'genera' such as *Merychippus* or *Cephalaspis*). The human stock is properly definable both as a minor clade (family Hominidae) and a major grade (Psychozoa).

G. Heberer (Western Germany) followed with "Zum Problem den additiven Typogenese"—on much the same general lines as the two previous papers. It was interesting to note the importance all three speakers placed on the researches of the American geologist, G. G. Simpson.

It was now the turn of the cryptogamic botanists, Roger Heim (France) dealing with "Les critères d'ordre chimique dans l'étude des affinités chez les Macromycètes". He examined in what degree the occurrence of certain chemical substances in fungi (either immediate products such as glycogen, chitin and cellulose, mannitol, trehalose, or pigments dissolved in vacuoles and fat globules in cells) can be used for supporting views in the general systematy of Mycetes. He showed that in certain cases—crystallized carotinic chondriocontes of spermatophytes and of fungi—such criteria have no taxonomic value. On the other hand, the presence or absence of a substance in a given group may provide strong confirmatory evidence of its status: such are the intercellular pigments of agarics with coloured spores, diphenylbenzoquinonic pigments. He gave examples of genera in which certain chemical substances are found in some only of the species but where all the species are obviously intimately related. He also gave examples of the strong correlation which can be seen between chemistry and certain anatomical structures. In his view biochemical criteria have a part to play in the controversies, hypotheses and confirmations of systematics, with its ultimate aim of a natural classification.

J. Feldmann (France) in "Remarques sur la Systématique actuelle des Algues" stressed the importance of cytological and biochemical characters for distinguishing large divisions (phyla) of algae as well as for characterizing orders. He showed, as an example, how the utilization of these characters during the past twenty years had brought about the splitting up of the Siphonales, formerly considered to be homogeneous.

Comparing systematics with taxonomy, the aim of which is essentially practical, he showed that in algae the search for natural affinities, the object of systematics, should make use of characters drawn from the living matter itself (morphology of the cellular constituents and biochemical peculiarities) rather than those furnished by morphology, anatomy and mode of reproduction. By convergence such characters can be the same in groups having no real affinities.

R. Tuomikoski (Finland) followed with a research summary "Über den heutigen Stand der Laubmoossystematik". Mosses are easy to collect and examine under the microscope so that at first their study made good progress along morphological lines. This resulted in their classification becoming more or less stereotyped, and during the past twenty years little research has been carried out to bring it more in line with modern ideas.

R. Pichi-Sermolli (Italy) gave an outline of "The Higher Taxa of the Pteridophyta and their Classification", making several proposals for modification and rearrangement.

The afternoon session opened with a philosophical discussion by B. Rensch (Western Germany) on "Die ideale Artbeschreibung".

I. Manton (Great Britain) urged that "The Concept of the Aggregate Species" should be used in floras, illustrating her remarks by reference to her work on *Polypodium*. The aggregate species *P. vulgare* is composed of *P. australe*, $2n$ chromosomes with a genotypic composition one might call B; *P. vulgare* s.s., $4n$ chromosomes with a genotype AC; and *P. interjectum*, $6n$ chromosomes with a genotype ABC. A second aggregate species would be *P. virginicum* with a microspecies with $2n$ (genotype A), and another with $4n$ (genotype AD).

R. C. Rollins (United States) in "Some Considerations of the Comparative Systematics of Vascular Plant Species" stressed the importance of comparative systematics in flowering plants, emphasizing that no single set of principles covers all the different types of variation which are encountered even within relatively narrow alliances. He instanced two genera of Cruciferae, *Lesquerella* and *Leavenworthia*, each with four species, having a striking parallel distribution in Tennessee. The variation pattern in these two genera, annuals occupying open habitats, is totally different. In *Lesquerella* the species are vicarious, and when artificially brought together, freely form hybrids, indicating the total lack of genetical sterility barriers. In *Leavenworthia* the species are sympatric, and highly incompatible with each other.

C. G. G. J. van Steenis (Holland) spoke on "Specific Delimitation, with Special Reference to Tropical Plants". He reviewed how far modern detailed research in genetics, experimental morphology, karyology and biochemistry has affected the basic value of the Linnean species. Though there is greatly increased insight of intraspecific structure the Linnean concept has been confirmed and has lost nothing of its actuality. The delimitation of genera and species is still the keystone of taxonomy, affecting botany in all its branches—pure and applied. From various points of view it is most unfortunate that botanical science in general, and taxonomy in particular, were not developed in the tropics instead of in countries with depauperated floras and disturbed vegetation. Systematists investigating tropical floras are concerned at the immense flow of experimental research which, while tending to undermine the species concept, simultaneously introduces 'characters' and delimitations which the systematist can neither test nor judge on their intrinsic merits.

W. Ludwig (Western Germany) then gave a paper "Artbegriff und Evolution der Art unter dem Aspect E. Geoffroys (Geoffroyismus)".

The next morning's session began with J. Clausen (United States) on "Function and Evolution of Ecotypes, Ecospecies and other Natural Entities". Genetic–ecologic experiments have shown that morphological and ecological characters that adjust ecological races to the environment are governed by fairly complex systems of genes composed of genes of the multiple kind which may have additive, subtractive, complementary, or epistatic effects in various proportions. The genes that regulate the individual character are usually located on different chromosomes, enabling fairly free recombination. They are distributed to the ecological races of a species in such a manner that one race may possess the genetic key that unlocks the heredity that is stored in another race. Interracial crossing accordingly results in the release of variability, in transgressive segregation, and in hybrid vigour.

Some of the genes that regulate different characters, however, are located on the same chromosomes, and accordingly cause moderate genetic linkage between distinguishing characters. The linkage is loose because only some of the genes of the system are linked. Such a genetic structure causes moderate genetic coherence, and permits moderate genetic recombination between ecological races. Ecological races, morphological subspecies, and closely related species function, therefore, as gene pools that store the potential variability of the genus in recognizable evolutionary entities or taxa, dynamic and flexible. Their genes regulate balanced processes adjusted to the seasonal and diurnal rhythms of the environment, an adjustment delicately balanced and requiring generations for development. A moderate genetic coherence is therefore an evolutionary necessity for proper survival. Natural selection has accordingly favoured such entities that possessed genetic structures sufficiently rigid to reproduce themselves as long as the environment remained essentially the same and that were sufficiently flexible to permit them to change in periods of geologic revolution.

W. B. Turrill (Great Britain) then considered "Genetic Variation within Taxonomic Species", taking most of his illustrations from *Silene maritima* and *S. vulgaris*. He emphasized the importance of habit characters as separating ecologically the two species and sub-species within them. Some of the variations experimentally proved to be genetical were definitely of survival value, others were deleterious, and others were doubtfully of survival value under the conditions now favoured by the different taxa. Some of the characters appear to be neutral in the sense of producing more or less balanced polymorphisms in many populations. The importance of considering the phenotype as a whole should always be kept in mind when survival value is being investigated.

J. Heslop Harrison (Northern Ireland) followed with "Ecological Variation and Ethological Isolation". Since the breeding system in a plant species is a dominant factor in determining its capacity for race formation, it is to be expected that differences will be found between anemophilous and entomophilous species in their patterns of infra-specific variation. In species which are specialized for a limited range of pollinators, persistent assortative pollination ('homogamy') in populations polymorphic for flower characteristics could provide the conditions for sympatric race formation, and this may have particular importance when it is accompanied by simultaneous ecological differentiation. Examples which appear to illustrate this are to be found among the European Orchidaceae, in several species of which ecological races exist that differ from each other morphologically only in the allæsthetic features of the flowers.

Z. Lorković (Yugoslavia) spoke on "Die Merkmale der unvollendteten Speziationsstufe und die Frage der Einführung der Kathegorie der Semispezies in die Systematik". In the newer especially experimental systematics it is becoming increasingly common to find that two populations can be classified either as true species or as races, and that in one of them at least the inner reproductive isolation mechanism is not fully developed. He proposed, therefore, to denote such an incomplete degree in speciation as a new taxon, semispecies or prospecies. Otherwise there is the danger of concluding that species and race mix, which must lead not only to faulty systematics but also to false evolutionary inferences.

F. A. Schilder (Eastern Germany) followed with "Versuch einer genetischen Klassification der Varianten bei Bänderschnecken". In the garden snail (*Cepaea hortensis*) variations in the shells are enormous, but there are great differences in frequency according to the presence or absence of certain genes in the populations. Though most varieties have been named scientifically, it seems to be more useful to design the characters of each specimen by a series of letters indicating its hereditary features in colour, banding, size, etc. When describing a population, the unit in biological evolution, one should indicate the percentage of varieties observed with regard to each independent character. The frequency of characters decreases concentrically from the locality where a character has been changed by mutation, and there seems to be scarcely any influence of environment on the progress of its distribution.

F. Ehrendorfer (Austria) in "Die geographische und ökologische Entfaltung des europäisch-alpinen Polyploidenkomplexes *Galium anisophyllum* Vill. seit Beginn des Quartärs" dealt with his cytogenetical and field-study research on this species. He stated that there were various polyploids (2, 4, 6, 8, 10-ploids) within the so-called species and related them to present-day ecological conditions and to those during and since the Glacial Epoch, and concluded that polyploids with the same chromosome number can arise in different ways.

B. Lövkvist (Sweden) dealt with the *Cardamine pratensis* complex in "Polyploidy and Ecological Differentiation". Chromosome numbers in pure-breeding populations range from 16 to 96 and the cultivated material can be divided into two morphological groups: the Temperate Group in which all the numbers occur, and the Arctic Group with only the numbers 64 and 80.

The components of the *C. pratensis* complex are ecologically well isolated from most other *Cardamine* species. New plants of all groups of the complex are self-incompatible. Therefore if only a few immigrants grow in a locality the number of self-incompatible alleles need be quite small. As hybrids are completely fertile hybrid swarms arise.

Field studies in south Sweden showed that populations with different chromosome numbers have different ecological preferences. High water-content of soil is the main adaptation factor: another is the biotic factor of competition. Vegetative reproduction is widespread so that it is necessary to decide whether plants growing in a special niche belong to a clone or constitute a population.

The last paper of the session was "The Taxonomic Treatment of Vicarious Taxa" by O. Hedberg (Sweden). The gradual differentiation of one species population into two or more independent taxa is a very complicated process. It seems well established that the rate of evolution may be greater in some features than in others. Thus the degree of genetical isolation between two closely related taxa is not always proportional to the amount of differentiation in gross morphology, chromosome make-up, etc. It is therefore dangerous to rely upon genetical isolation as an unfailing criterion for specific distinction. Though experimental methods are greatly aiding our understanding of many points in evolution they cannot be applied within the foreseeable future to more than a fraction of species described, and so to

be able to write consistent accounts of floras we are compelled to retain the traditional taxonomic hierarchy.

When closely related taxa inhabit mutually exclusive areas the sole criterion for taxonomic distinction is the occurrence of discontinuous morphological variation. The taxonomic treatment of such 'geographically vicarious' taxa may often offer considerable difficulties.

Good examples are provided by the floras of the high East African mountains where the alpine biotas are completely isolated. Within several genera examples occur where the populations of different mountains are taxonomically distinguishable, forming groups of vicarious taxa. Recent studies have revealed numerous intermediate types which are difficult to classify. Some species occur in isolated populations on many or all of the mountains with no perceptible morphological differentiation; in others, different mountain populations of one species show statistical differences, but their variation-ranges overlap so as to make taxonomic distinction impossible; whereas in others there are distinctly discontinuous variation-ranges in one or more features. As a working rule the author chose to demand clearly discontinuous variation in at least two independent characters for specific distinction, and one clear discontinuity for subspecific. But numerous intermediate stages of differentiation exist.

The last session began with a short account by J. Ramsbottom (Great Britain) of the precautions taken by the Linnean Society of London and by the British Museum (Natural History) for the protection of Linnaeus's collections during the Second World War.

F. Widder (Austria) then spoke on "Die geographisch-morphologische Methode als abgestufter Verwandtshaftstest".

H. Merxmüller (Western Germany) followed with "Einige Probleme der Sippengliederung und Arealbildung in den Alpen", in which he considered the so-called 'Tischler's rule' that in the flora of a given region there is a constantly increasing proportion of polyploids from south towards north. He gave reasons for holding that Tischler's rule must be restricted to two types of region—mountainous areas where the various biotypes widely separated in the plains come closely together, and regions strongly sculptured during the glacial epoch where different wandering floras could meet. It should, therefore, apply to the Alps, but many Swiss authors have concluded otherwise. The author thinks the discrepancy can be explained by regarding the heavily glacier-worn Central Alps and the bordering regions which were not glaciated, where old floras often of Mediterranean or Asiatic origin have been conserved, and often succeeded in re-entering the blanks left by the receding ice. This very considerable portion of old prediluvial types in the present alpine flora interferes with statistical results. The apparent failure of the rule is explained by the fact that the percentage of polyploids in the Alps has been compared with that of the regions north of them in Central Europe instead of the regions south, east and west, which were only slightly disturbed in the glacial period.

J. Iversen (Denmark) discussed "The Bearing of the Glacial and Interglacial Epochs on the Formation and Extinction of Plant Taxa". Conditions that favour the formation, or, reversely, the extinction, of plant species differed greatly in the course of one great cycle of glacial and postglacial (interglacial) succession. The period of maximum cold (full glacial) appears to have been purely destructive. The following stage was constructive, due to rising temperature combined with slight competition only; light was adequate, the immature soil basic or neutral. Later, optimal temperature and soil conditions favoured dense forest growth; shade-intolerant species were suppressed or became rare relics. In the last stage the destruction of the flora was accelerated by climatic decline and soil degradation. Agriculture greatly modified this course, which applies to north-western Europe specifically.

G. E. Du Rietz (Sweden) speaking on "The Hybrid Concept" and illustrating his remarks with particular reference to New Zealand was concerned mainly with the nomenclature of what are generally known as hybrid swarms.

B. Petersen (Sweden) demonstrated "*Pieris napi* and *P. bryoniae*, two 'Siamese twin species'". These species are sympatric in the Alps and in the Carpathians. In Scandinavia similar forms are allopatric and connected by geoclines. Common descent and not reproductive communication should in such a case be decisive for the taxonomic treatment of the group.

G. Svärdson (Sweden) continued the Swedish contributions with "Interspecific Hybrid Populations in *Coreogonus*". The morphological and ecological variation is great. The variation, however, is mostly environmental and only partly genetical. Therefore, to establish a firm basis for the study of speciation in this fish group, some characters must be found which are genetically determined and have only a low capacity for environmental modification. Experiments still in progress were begun in 1944. Special attention was paid to gill rakers as they have been used extensively in *Coreogonus* taxonomy.

If a whitefish population is transplanted to some new lake the morphology may be drastically changed, but the gill rakers are stable. If individual fish with extreme numbers of gill plates are selected and bred from, the progeny responds to the selection, indicating a polygenic inheritance of the gill raker numbers. Finally, if two sympatric or allopatric species of whitefish are artificially crossed, their hybrids are intermediate in gill rakers, again indicating polygenic inheritance.

Within the species-groups, introgression occurs very frequently and often in such abundance that the original species can no longer be identified with certainty. Introgression may be followed by replacement and the surviving population then shows some characters of the species which has disappeared.

As sibling species of whitefish and ciscoes have lived sympatrically in thousands of European lakes since the glaciers retracted, they cannot possibly be called a sub-species. Distribution data show that they have invaded the Scandinavian peninsula at different times and they certainly have an allopatric origin.

The final paper of the symposium was also by a Swede, B. Pejler, on "Taxonomical Studies on Planktonic Rotatoria". The local variation is often considerable. Sometimes a connexion exists between the local variation and the environment. At others a variation has been established which might best be explained as the result of introgressive hybridization between closely related species. The study of the

variation within particular complexes of forms, which have previously been regarded as a single species, often reveals a discontinuity in size or other characters, indicating the occurrence of sibling species. By reason of certain facts it is assumed that the Rotatoria consist to a smaller degree of cosmopolitic forms than has been believed previously.

After the strenuous symposium it was a delight to be conducted along parts of Linnaeus's Herbatio gottsundensis by Prof. G. E. Du Rietz; it was described by Linnaeus in "Herbationes upsaliensis", 1753. Apart from the rich flora there was the satisfaction of seeing many plants which Linnaeus had demonstrated to his students. It was surprising to see *Fritillaria meleagris* growing in woodland. (On the journey back to headquarters the extensive 'King's Meadow' was visited, where it occurs in enormous numbers. It is there protected, and is so much an Upsala feature that it figures on the cover of the official guide.)

Other places of botanical interest were visited, and after lunch, Hammerby, Linnaeus's summer residence. Here there was a meeting of the Royal Society of Science of Upsala, and Prof. N. von Hofsten read a paper on "Linnaeus's Conception of Nature". Hammerby was looking at its best, and several of the plants introduced by Linnaeus were in full bloom.

The foreign members of the Symposium later all signed a memorandum recommending that Herbatio gottsundensis be set apart as a nature reserve.

Appropriately there was a dinner and reception in the evening at Smålands Nation, the student corporation of which Linnaeus was 'inspector'. An apple tree from his birthplace was planted in its 'native' soil, and the significance of this in Swedish lore explained by the inspector, Prof. C. Nylén, who later gave a short address on the Smålands Nation; Dr. A. Uggla spoke on Linnaeus as a Smålander and Mr. J. Beskow, the curator, on student life in Upsala.

The end-of-term ceremonies with the 'promotions' of doctors were held on May 31. For the most part they followed tradition, beginning at 7 a.m. with a salute by cannon, one for each doctor, to be followed at 8 a.m. by bell-ringing from the cathedral. At 12 a.m. a procession was formed, and passed into the aula of the University, everyone in white tie and evening dress and the honorary doctors in academic robes: the order of procession gives nineteen entries, individuals and groups. The proceedings began with a discourse by Prof. S. Hörstadius, promoter of the Matematisk-naturvetenskapliga fakulteten, on "Linné, djuren och människan". To accompanying orchestral music those to be promoted were grouped in the five faculties, each with its own promoter; first the jubilee doctors (of fifty years standing), then the honorary doctors, finally those who had achieved success by thesis. The name is called, the three steps of the cathedra superior ascended, a laurel crown (or a top-hat) placed on the head (accompanied by a cannon-shot without), a gold ring put on the finger, a diploma presented, a shake of the hand, a descent from the cathedra and a pause and a bow to H.M. the King of Sweden, who sat just below the platform. The three-hour ceremony was impressive and picturesque with its savour of the medieval and its national significance: it ended with the students acclaiming the jubilee and honorary doctors assembled on the steps of the University in song and speech.

The programme of the ceremony was adorned with a representation of a laurel wreath surrounding *Linnaea borealis* and the words "Tantus amor florum". It includes the "Promotions-formulär" employed by Linnaeus for the medical faculty on October 31, 1754.

Among the recipients of honorary degrees (Fil.Dr.) were H. H. Allan (New Zealand), Julian Huxley and J. Ramsbottom: A. H. Uggla, the well-known authority on Linnaeus, was promoted doctor of medicine.

Attention should be directed to the "Inbjudningar till Doktors-Promotionerna", as it has an appendix of four important papers: F. Berg, "Linnés Systema morborum" (132 pp.); A. Liljencrantz, "Kungl. Vetenskaps-Societetens protokoll 1732–1784" (97 pp.); G. E. Du Rietz, "Linné som myrforskare" (80 pp.) and Å. Holm, "Specimina Linnaeana i Uppsala bevarade zoologiska samlingar från Linnés tid" (68 pp.).

The menu card at the graduation dinner held in the Castle was a reproduction of the frontispiece to the rare "Linnéska Institutets Skrifter"—a few hand-coloured copies of this were found recently in the archives of the Royal Society of Sciences, Upsala.

The celebrations ended on June 2 with a commemoration meeting of the Swedish Linnean Society at Hammerby. The annual pilgrimage this year marked also the fortieth anniversary of the Society. The President repeated his discourse of Thursday, though this time in Swedish: he was followed by A. G. Boerman, a Dutch medical man, who attempted an analysis of Linnaeus's character by reference to his youthful notes and writings. In glorious weather about two hundred had an alfresco lunch, at the end of which the veteran student of Linnaeus, Prof. Robert Fries, spoke of the beginning of the Society of which he was co-founder, of its objects and of the Linnean tradition. The meeting ended at Linnaeus's old house and garden at Upsala—the headquarters of the Society.

It was a memorable week, and all who took part in the celebrations will long remember the courteous and lavish hospitality of our Swedish hosts, the understanding tributes to Linnaeus, the international friendliness of the symposium—and Upsala in spring.

NATURAL RUBBER INDUSTRY

RESEARCH AND DEVELOPMENT

THE natural rubber industry is made up of units varying enormously in size, ranging from very large estates with their own modern and well-equipped factories to smallholdings, some processing their rubber in primitive fashion, others making use of co-operative equipment. The organization of research and development schemes to assist these diverse elements began naturally enough with the creation, in Ceylon and Malaya, of institutes concerned in the main with agronomic problems and with the provision of advice to growers. The success of these institutes is reflected in the substantial increases in yield—per tree or per acre—which are now being obtained, and in a steady advance in the general quality of the rubber produced.

The first appearance of synthetic rubber was probably a major stimulus in bringing some of the industry's leaders to feel that a more substantial and broadly-based effort in research and development was called for if natural rubber was to advance, or even hold its own, in a more challenging situation. The catastrophically low prices of the early 1930's showed that the industry was exceedingly vulnerable.

The British Rubber Producers' Research Association and the Natural Rubber Development Board (as it is now called) were formed some twenty years ago, and have been financed mainly by money raised by the Malayan rubber industry. Throughout their existence they have co-operated with the Eastern institutes and with sister organizations set up about the same time by the Dutch and French rubber growers. They have, however, retained their essential independence, under the control of their several boards.

In recent years the bulk of the income of the two British bodies and of the Rubber Research Institute of Malaya has been obtained from a single fund derived from a cess on Malayan rubber exports. The Malayan Rubber Producers' Council very reasonably decided some time ago that it would be useful to review the whole organization which had grown up and to consider what changes, if any, were now desirable. The report of the committee charged with this task has now been published*, and gives an overall impression of general approval, modified by some criticisms of detail.

The membership of the committee had a strong agricultural bias, and many will feel it unfortunate that the rubber manufacturing industry was unrepresented. This unbalanced composition has led to a corresponding unbalance in the report: whereas the programmes of the Rubber Research Institute are subjected to detailed criticism, the work of the British Rubber Producers' Research Association and of the Natural Rubber Development Board is not examined in quite the same way. At the same time, the most valuable features of the report are probably the review of the objectives of the three bodies considered together rather than separately, and the recommendations as to administrative changes which are considered desirable. Numerous detailed recommendations are made, most of them of interest primarily to those directly concerned with the several bodies involved. In general they appear very sound and reasonable, and their acceptance would seem probable. The need for higher salaries to attract the right men, especially for service in the East, is cogently argued, and puts the correct emphasis on quality.

The implementation of this report will cost the industry more money: it is recommended that the cess on rubber exports be increased by 50 per cent, to yield an annual income of approximately a million pounds sterling. It is pointed out that this will still represent a substantially lower percentage of the sales than is normal in the chemical industry, which—as the supplier of synthetic rubbers—must be considered the chief competitor. The natural rubber industry has through the years been fortunate in the quality and vision of its leaders. It can be confidently assumed that this report will receive the attention and action it deserves.

G. Gee

* Report of the Advisory Committee enquiring into Production Development and Consumption Research in the Natural Rubber Industry. Pp. v+49. (Kuala Lumpur: Rubber Producers' Council of the Federation of Malaya, 1957.) 2 Malayan dollars.

THE MEDICAL RESEARCH COUNCIL

REPORT FOR 1955–56

THE report of the Medical Research Council for the year 1955–56* follows the pattern of earlier reports in giving only summaries of the work of the Council's many separate research establishments. The fullest account of their work is contained in the scientific papers published by the Council's staff, bibliographical references to which occupy sixty-six pages of this report. The main part of the report discusses general trends in medical research, a discussion which is, as the introduction emphasizes, selective and omits many investigations in which the Council's workers take part. The introduction also reminds us that virtually every conspicuous advance in knowledge depends on a mass of unspectacular, but indispensable, work done by many individuals, or by teams of workers, who bring different kinds of knowledge and skill to bear upon complex problems and are often themselves unable to make the final contribution to which outstanding advances are due.

It is, of course, impossible to review in a short space all that this report contains. Apart from the details it gives of the personnel employed by the Council, the various committees which direct the work done, the research units and the summaries of the work that these units are doing, there are, in the report, articles on clinical investigations and on research in genetics, as well as forty-seven pages devoted to various aspects of medical research.

The clinical research dates back to 1951–52, when the annual report of the Council reviewed the effect of recent scientific and administrative developments on the organization of such work. Later, the Council was invited to discuss with the Standing Medical Advisory Committee of the Ministry of Health how clinical research could be encouraged and developed in relation to the National Health Service, and an interdepartmental committee, under the chairmanship of Lord Cohen of Birkenhead, was set up to examine the question. Its report, published as a White Paper in 1953, recommended that the Medical Research Council should appoint a Clinical Research Board, and in 1953 this was done.

The Council has always maintained that its investigations should neither supplement nor replace those carried out in universities, medical schools or hospitals, but should be complementary to work done in these centres, and this report describes, in considerable detail, how the Council is doing this. In general, the Council supports clinical research by setting up units made up of its own staff, by appointing its staff to work at centres other than the Council's own establishments, by making temporary grants to workers not on the Council's staff, by making awards for the training of research workers and by organizing co-operative clinical studies. The Council is concerned with three clinical research establishments in the tropics—at Fajara in the Gambia, at the Infantile Malnutrition Research Unit at Kampala in Uganda, and at the Tropical Metabolism Research Unit at Kingston, Jamaica; and the Council hopes to develop links between these centres and clinical research units in Britain. The estimated cost of the expanded programme of clinical research for the

* Committee of Privy Council for Medical Research. Report of the Medical Research Council for the year 1955–1956. Pp. vii+270. (Cmnd. 180.) (London: H.M. Stationery Office.) 9s. net.

current year, excluding that in the tropics, is of the order of £700,000.

Provision is also to be made for research organized at the level of regional hospital boards, boards of governors and hospital management committees; in this field there is to be the greatest possible freedom from detailed supervision, so that the development of local talent can be fostered.

Research in genetics is not a new activity of the Council. More than twenty years ago it began to develop work in this field. At that time although great progress had been made in the biological study of heredity and in the application of the results of this work to agriculture, human genetics had been neglected and there was need for studies of problems of inheritance and disease in man. This need was later radically increased by developments in the use of nuclear energy. The fact that exposure to radiation could cause fundamental changes in reproductive cells had been known since H. J. Muller first observed it in 1927, but the general increase in the amount of radiation to which individuals and whole communities could be exposed gave rise to the fear that man's hereditary constitution might thereby be permanently endangered, and it was clear that workers must be trained for the study of this general problem.

The Council has therefore established, during the past ten years, a number of research units to follow various lines of investigation of this kind, and observations are being made both on man and on animals. It is expected that expenditure on this kind of work will, in 1960, rise to £100,000 a year. The Council wishes it to be widely known that its scholarships and clinical fellowships provide specialized training in certain genetical methods, and that there are now good opportunities for research careers in university departments, or as members of the Council's staff. In 1955, a committee was appointed to report on the medical aspects of nuclear radiation, including its genetic aspects, and this committee dealt also with the wider problem of the hazards to the community as a whole, or to particular sections of it, which might arise from the use of nuclear and allied radiations. Its report, which was presented to Parliament in 1956 as a White Paper, has now been made available to the United Nations and will be translated into Japanese, German, French and Italian.

The section of the report entitled "Some Aspects of Medical Research" includes, this year, an article on recent advances in the study of the factors that may cause cancer of the lung, an article which reviews the evidence for and against the thesis that tobacco smoke is the only cause. The Council is supporting an expanding programme of research into lung cancer which will study the various possible factors involved, particularly tobacco smoke, and will also test the carcinogenic properties, if any, of substances obtained from the chemical analysis of tobacco and from its combustion.

Other subjects discussed in this part of the report are poliomyelitis vaccination, the prevention of whooping cough by vaccination, filariasis, protein deficiency in man, growth and renal function, microbial genetics, abnormal hæmoglobins and their relation to disease, problems of radiation, the chemistry of proteins and of antibiotics, and the use of the mass spectrometer for gas analysis in respiratory research and clinical practice.

The administration and finance of the Council's multifarious activities are dealt with in other sections of the report which, together with the details of the personnel and many research units and the summaries of their work, afford a clear picture of a great body of scientific work directed to the preservation of health and to the prevention of disease. One is impressed by the vigour of the work in hand, its forward outlook, its breadth and the depth of detail to which it penetrates. It is to this detail and to the Council's flexible control, and most of all to the devoted work of the Council's numerous staff that the results obtained are due. Much of the credit should go to those many members of staff of the Council who cannot, as the report itself points out, make the final contributions, based on their work, which the public, from time to time, acclaims. G. LAPAGE

RESEARCHES IN MARINE BIOLOGY

THE recent issue of the *Journal of the Marine Biological Association of the United Kingdom* (36, No. 2; 1957) contains eighteen papers, of which ten are on work done at Plymouth; three come from Millport, two from Aberdeen, and one each from Oregon State College, Belfast and Burnham-on-Crouch. In addition there are abstracts of fifteen other papers on work done at Plymouth but published in other journals.

The eighteen papers can be roughly divided into five groups: (*a*) botany (1 paper); (*b*) natural history and descriptive zoology (7); (*c*) fish (2); (*d*) physiology and biochemistry (4); (*e*) plankton production and hydrology (4).

(*a*) *Botany.* The single botanical paper is an exhaustive taxonomic study by H. T. Powell of a very variable northern species of *Fucus*, *F. distichus*, the nomenclature of which had reached a state bordering on utter confusion. The main specific characters are the hermaphroditic conceptacles and certain closed cavities in the frond called 'cæcostomata'. There appear to be four principal subspecies, of which one reaches Shetland and one Scotland and Ireland; the species is not known to occur in English waters. From its title, this paper would appear to be the first of a welcome series.

(*b*) *Natural history and descriptive zoology.* There are two papers on copepods associated with other animals.

R. U. Gooding adds a number of new Plymouth records of copepods associated with spatangids, lamellibranchs and fish. Three new species are described, of which one is the type of a new genus.

R. V. Gotto describes the biology of the commensal copepod *Ascidicola rosea* in the very transparent ascidian *Corella parallelogramma* in Strangford Lough, Northern Ireland. The copepod normally lives in the œsophagus of its host, feeding off the mucous food-string as the latter passes by on its way to the ascidian's stomach. The copepod can climb up and down the food-string by means of specialized spiny pads and setæ. Eggs are shed in the ascidian's stomach, pass down the alimentary canal and, conveniently, hatch only on reaching the anus. There is a free-swimming life of about six days, and the host is entered by the second copepodite.

J. Llewellyn describes the larvæ of eleven species of monogenetic trematodes from Plymouth fishes. It is difficult to fit the larvæ so far known (35) into the scheme of classification now in use for the adults, and Llewellyn suggests modifications of the adult

scheme in order to reconcile it with what is shown by the larvæ.

F. S. Russell describes yet another new species of deep-water scyphomedusan (*Atolla vanhöffeni*) brought in by the appropriately named R.V. *Sarsia*.

R. Phillips Dales, investigating the feeding of serpulid and sabellid fan-worms, finds that smaller worms filter relatively faster than larger worms, but that a fan-worm filters more slowly than a lamellibranch or an ascidian of the same weight. Fan-worms seem to depend mainly on inert particles for their subsistence; small flagellates, etc., can escape through the ciliated crown. The polychæte sorting mechanism is relatively crude.

A. J. Southward, continuing his studies on barnacles, investigates the effects of temperature and age on five more species. There is a rough correlation between the range of temperature over which the cirri are active and the geographical range of the species, but this correlation is by no means precise; the world-wide *Lepas anatifera*, for example, is active over a surprisingly narrow temperature-range at Plymouth.

J. E. Morton, A. D. Boney and E. D. S. Corner describe the adaptation of the small, abundant, high-level shore lamellibranch *Lasaea rubra*. Those living higher on the shore are better able to resist desiccation, start feeding sooner after wetting, filter more water in a given time, respire faster and are more tolerant of changes in salinity, than those living farther down the shore.

(*c*) *Fish*. There are two papers by T. B. Bagenal, the first being on the long rough dab (*Hippoglossoides platessoides*) in waters near Millport. The condition of the fish (based on the weight–length ratio) is at a maximum in mid-winter, and at a minimum during the spawning season in March and April, after which it recovers again. In the second paper there is a discussion at some length on the statistics of fecundity in the long rough dab and also in the plaice.

(*d*) *Physiology and biochemistry*. Dorothy Collyer, in an attempt to find causes of the variations in mortality-rate that occur between different batches of oyster larvæ, finds that there is no correlation between size or viability of larvæ and their glycogen content.

There are two more papers by J. A. C. Nicol on luminescence in polynoid worms. Separate elytra, electrically stimulated, can respond by quick flashes (which may be single or multiple) or by a luminescent glow. There is evidence for functional polarity in the nerve cord; to quote Nicol, "luminescent excitation is conducted with greater facility posteriorly over a large part of its length".

D. B. Carlisle, continuing his work on the hormonal inhibition of moulting in decapod Crustacea, examines the 'terminal anecdysis' in crabs. Some species of crabs reach a finite size after which they do not moult again. *Carcinus* moults several times after puberty, but eventually the *X*-organ produces so much moult-inhibiting hormone that further moulting is impossible unless the *X*-organ is removed. In *Maia*, on the other hand, the last moult is at puberty; by that time the *Y*-organ (which produces a moult-promoting hormone) has degenerated, and no more moults are possible even after removal of the *X*-organ. In an interesting appendix Carlisle suggests that the heaps of *Maia* which can sometimes be seen in autumn are a device not only for bringing males and females together for breeding (they can breed only once in a lifetime) but also for protecting the soft, newly moulted females by an outer layer of hard males.

(*e*) *Plankton production and hydrology*. There are two papers by John H. Steele on water samples from the Fladen grounds in the North Sea. In one, on oxygen sampling, a conversion factor for the ratio oxygen–phosphorus is calculated, and problems concerning production and surface exchange are discussed. In the other paper, carbon-14 and phosphate data are compared as means for estimating plant production. The two methods give results which vary in detail but are in general agreement. The carbon-14 method is better for measuring plant production at a particular time, but the phosphate method is better over a period.

Wayne V. Burt reappraises the data of Jones and Wills (1956) on the attenuation of light in the sea, and suggests how they can be used for estimating particle-size.

F. A. J. Armstrong continues his annual surveys of phosphorus and silicon off Plymouth. In general, the hydrographic conditions at International Station *E*1 showed the usual changes. Phosphate, however, was higher in February than at any time since 1929; in spite of a cruise in the western approaches by L. H. N. Cooper, the source of this phosphate-rich water was not discovered. In July and August there was an influx, especially into the deeper layers, of relatively cool water of lower salinity.

John S. Colman

A WILSON CLOUD CHAMBER WITH TIME-MARKING OF PARTICLE TRACKS

By Dr. D. GABOR, F.R.S., and B. HAMPTON
Department of Electrical Engineering, Imperial College of Science and Technology, London

In Wilson cloud chambers using magnetic fields, the momentum of the particles can be determined directly by measuring the curvature of the tracks, but the velocity (energy, mass) only indirectly, from the observation of recoil electrons, ionization density and other observations. It would therefore be desirable to possess an instrument which puts time marks on the tracks, at equal intervals of the order of 10^{-10} sec., to allow a direct measurement of velocities. One of us (D. G.) has proposed achieving this by turning the Wilson cloud chamber into a resonating microwave cavity, which operates with an almost uniform high-frequency field so near to breakdown that considerable multiplication of secondary electrons takes place near every peak, producing a periodic thickening of the tracks. This would also make possible the observation of emission delays of the order 10^{-11} to 10^{-10} sec. in nuclear events.

A high-frequency field near the breakdown limit supplies to electrons energies such that an appreciable fraction will create at least one further pair during their life-time. But if the life-time is long, as in inert

gases, the instant of creation of the first electron is of no importance. On the other hand, in gases with strong electron attachment, such as chlorine or 'Freon', the life of a free electron at atmospheric pressure will be of the order of 10^{-10} sec., comparable with a half-cycle of a field of, say, 3,000 Mc./sec., which is $1{\cdot}67 \times 10^{-10}$ sec. Few electrons will then survive into the next cycle, and one can expect considerable excess ionization in the case of secondary electrons created just before the field goes through a peak. This will produce a modulated track, thickened at intervals of $\frac{1}{2}\ \beta\lambda$, without any significant distortion of the track, so that it would not prevent simultaneous measurement of the momentum.

It is almost immediately evident that the successful realization of such a scheme is mainly a question of adequate power. The breakdown field of air at atmospheric pressure at microwave frequencies is about 28 kV./cm., which corresponds to a peak energy of 4×10^{-5} joule/cm.^{3}. This must be renewed ω/Q times per second. With a frequency of 3,000 mc./sec., ($\lambda = 10$ cm.) and $Q = 1{,}000$, this works out as 750 watts/cm.^{3} of useful volume. In 'Freon', with a breakdown strength of about 90 kV./cm., it would be about 10 kW./cm.^{3}.

These would not be considered as unusually high powers if one could confine the pulse to a few microseconds, because large pulsed magnetrons are in existence which can deliver 2–4 megawatts for such short durations, and klystrons even ten times as much. The scheme would therefore not offer great difficulties if the cavity cloud chamber could operate near an accelerator so powerful that it produces several tracks of interest per microsecond (using an electron-optical shutter to keep off the beam for the rest of the sensitive period of the cloud chamber). But in the experimental investigation to be described, which we started in 1954 to pave the way for more ambitious schemes, we had to confine ourselves to rather weak radioactive sources. These supply a few α-tracks in about 10 msec., which is of the order of the sensitive period of ordinary cloud chambers. We were fortunate in obtaining for this work, by courtesy of the Research Laboratories, General Electric Co., Ltd., the experimental magnetron *VX* 3043, one of the largest d.c. magnetrons in existence; but even with this we could not obtain more than 2·2 kW. output at 3,000 Mc./sec., in pulses of 15 msec. duration. Though by careful design of the microwave circuit we were able to direct 90 per cent of this into the cloud chamber cavity, the 'loaded Q' could not be made larger than about 500. This would be just sufficient for 0·1 cm.^{3} of 'Freon', if it were possible to make the field uniform in the whole volume. We had therefore to confine our experiments to the diatomic gas with the lowest breakdown strength, which is hydrogen (15 kV./cm.). This left us only with a marginal chance of success, because the electron attachment of hydrogen is negligible.

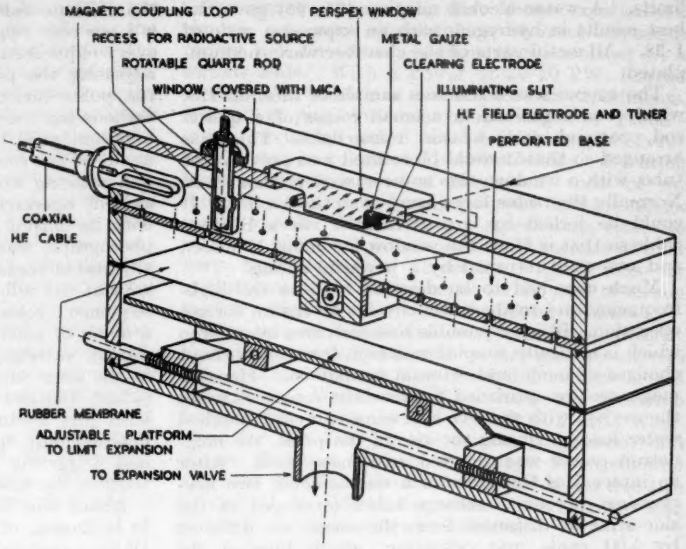

Fig. 1. Cavity cloud chamber

It has, however, an appreciable slowing-down effect on electrons below its ionization energy (about eighty times larger than the elastic fractional loss $2m/M$). Though a secondary or tertiary electron survives over a very great number of cycles, its probability of rising above the ionization-level decreases rapidly after the first half-cycle in which it was created. This enabled us to obtain some measure of success with the apparatus now to be described.

The cavity cloud chamber used in the final experiments is shown in Fig. 1. The cavity is rectangular, with a re-entrant plunger which concentrates the field in a rather small fraction of the total volume. This is faced by a 'Perspex' window, for observation, also re-entrant, which is covered with a copper or silver gauze, fine enough not to obstruct the photography if one uses an optical system of small focal depth. The bottom of the cavity is a perforated metal plate, and the expanding part of the chamber is below it. This makes it possible to keep the walls of the cavity free from condensed water or alcohol, which would appreciably spoil its resonant properties. These were, of necessity, rather poor, because one cannot concentrate the field of a cavity operating with a wave-length λ into a volume with a base less than about $\lambda^2/4$ without reducing the Q well below its optimum value, and this was further reduced by the illuminating slit and by the gauze-covered observation window. This was the reason why the Q of the cavity by itself was only about 1,000, and the loaded Q 500, whereas without the plunger and the re-entrant window one can obtain about four times as much. In other words, once power is scarce, one cannot get the full benefit of restricting the volume.

The expansion was effected by a thin rubber sheet (latex), which closes the bottom of the space below the perforated plate. When the vacuum valve is opened this settles snugly against the walls and against a movable platform which permit adjustment of the expansion ratio between rather wide

limits. A water–alcohol mixture (35 : 65) gave the best results in hydrogen, with an expansion ratio of 1·38. All metal parts of the chamber were rhodium-plated.

The source was a 0·1 mc. sample of thorium-228, which was contained in a small recess of a quartz rod, covered with a thin mica flake. This was arranged so that it could be rotated in a polystyrene tube, with a window, also covered with a mica sheet. Normally the recess faces away from the window. It could be jerked by a push-magnet *via* a Bowden cable so that it faced the window for about 15 msec., and was then returned by a powerful spring.

Much care had to be devoted both to the high-frequency and to the pulse circuits to ensure correct operation. It is not possible to switch on a magnetron which is critically coupled to a high-Q cavity without changes of mode and internal breakdown. Hence a magic tee was provided between the magnetron and the cavity, with the two side-arms carrying matched water loads. During the rise of the pulse, the magnetron power was directed into these loads. After an interval of the order of a microsecond, two low-pressure mercury discharge tubes (arranged in the side-arms at distances from the magic tee differing by $\lambda/4$) came into operation, which blocked the flow to the water loads and directed 80–90 per cent of the magnetron power into the cavity, through a matching transformer, a coaxial cable, and the coupling loop shown in Fig. 1. The fields in this loop were very strong, and it had to be cast into paraffin or polystyrene to prevent sparking.

In order to obtain powers of the order of 2 kW. from the magnetron *VX* 3043, the thoria cathode had to be kept hotter than could be achieved by the heating coil alone. It was therefore kept in continuous operation with 200 watts output and pulsed 4 times per sec. with the full pulse power, which was 4·25 kW. (5·3 kV., 0·8 amp.). With somewhat less than 50 per cent efficiency, this gave a total power of 2·2 kW. for 15 msec. The pulse power was obtained from a large 6-phase rectifier, with a peak-to-peak ripple of 5·7 per cent. As the ripple frequency was 300 c./sec., there were 4½ ripple-cycles per pulse.

It was evident from the start that in order to achieve success it was necessary to have very flat-topped pulses of accurately adjustable height, and very small ripple, so that the high-frequency field could be kept just below breakdown. We achieved this by using a large choke of 50 H. which was permanently excited with a d.c. current of the same strength, about 0·8 amp., which the magnetron required during the pulse. This choke was short-circuited when the magnetron was not in operation, and was placed in series with the magnetron immediately after the start of the pulse by opening the short circuit. The choke instantaneously impresses its own pre-set current on the magnetron, and at the same time reduces the ripple to ½ per cent peak-to-peak. The current then changes exponentially from the pre-set, initial value to its ultimate value, determined by the rectifier and proportional to the mains voltage, with a time constant of 5 msec. Maximum constancy is achieved if the initial and the ultimate values are the same; there is then only a ½ per cent ripple in the otherwise flat top. Before every experiment, a number of trial runs were made, adjusting the pre-set choke current to be equal to the pulse current, by observing the flat top on a cathode-ray oscillograph. Both were then raised together, until breakdown in the cavity occurred in about 50 per cent of the trials.

A rotating switch system, including a high-voltage switch, operated the magnetron 4 times per sec., with its output going into the water load. When a photograph was to be taken, a second shaft with adjustable cams was coupled to the switch system, so that the following operations were carried out in sequence: release of the expansion valve (which had a delay of about 75 msec.), rotating the radioactive source, switching on the high-voltage pulse, which at the same time was applied to the discharge tubes (which blocked off the water loads automatically, with just about the right delay of the order of a microsecond), opening the short-circuit of the choke, and triggering the camera shutter which in turn triggers the flash-tube system used for illumination.

About four hundred photographs have been taken in hydrogen, of which about half led to breakdown. Of the remaining 190, two photographs showed clearly one modulated α-track each. These are reproduced in Fig. 2. Both have nodes spaced by 2·7 mm., which corresponds to $\beta = 2{\cdot}7/50 = 0{\cdot}054$, in good agreement with the velocity of α-particles of this source, at this part of their range. It may be noted that all the other α-tracks—there were nearly a thousand—which were sharp enough to show up modulation if it had existed were smooth and even, so that these two tracks with three evenly spaced nodes each cannot be explained by accidental grouping of nodes. Nor was any modulation observed in several hundred photographs taken without high-frequency fields.

In view of the precautions we have taken to ensure a field close to breakdown, these results might suggest an extremely narrow useful field-range in hydrogen; but closer analysis shows that the observed yield of about one modulated track in five hundred is quite compatible with a useful range of several per cent. The main reason for this is in the characteristic of magnetrons. In the high-output region in which we have operated, 1 per cent variation of the magnetron current produces 13 per cent variation in the output power, and 6 per cent in the field intensity. Hence the ½ per cent ripple in the current produced a 3 per cent ripple in the field. Moreover, if the pulse current supplied by the rectifier, which is propor-

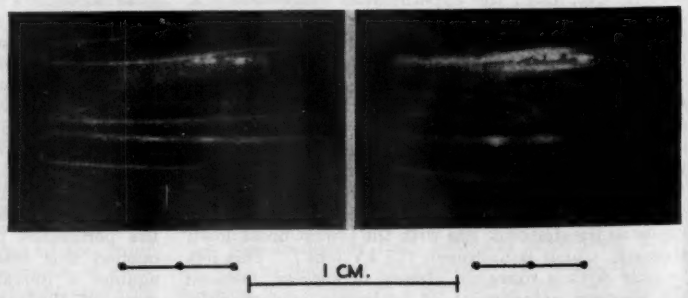

Fig. 2. α-Tracks of thorium-228 in hydrogen, modulated with 3,000 Mc./sec.

tional to the mains voltage, departs by only 1 per cent from the current pre-set in the choke, the voltage will rise or fall by 3 per cent during the pulse. We have calculated that if the pre-set value of the current departs only by $\pm\frac{1}{2}$ per cent from the optimum value, and the mains voltage fluctuates also by $\pm\frac{1}{2}$ per cent around the optimum, the useful time in all photographs, assumed as the time in which the field remains within 1 per cent of the breakdown strength, is only 3 per cent in those trials which do not lead to breakdown. It is likely that our accuracy of adjustment was nearer ± 1 per cent than $\pm\frac{1}{2}$ per cent, which makes this fraction only 0·5 per cent. It is also very likely that the useful part of the chamber volume, that is to say the fraction in which the field intensity differed by less than 1 per cent from the maximum, was not more than 1/10. (Note that both modulated tracks are nearly in the same position.) This would lead to an expectation value of about 1 : 2,000; hence the observed yield of 1 : 500 is quite compatible with a field-range of 2–4 per cent below breakdown suitable for producing clearly modulated tracks of α-particles. This confirms us in our opinion that the two photographs shown in Fig. 2 are not freaks.

We believe, therefore, that these experiments, though not very successful in themselves, augur rather well for the application of the method on a serious scale. With a power of 20–40 kW. instead of the 2 kW. which was available in our experiments, it would be possible to use chlorine–argon or 'Freon'–argon mixtures, with a breakdown strength of 40–60 kV./cm., in volumes of reasonable size. By using large klystrons instead of magnetrons, most of our difficulties in accurately adjusting the field-intensities would vanish. Moreover, our experiments relate to α-tracks, which are rather unsuitable because of their very high degree of ionization. Conditions for modulation would be far better in the case of meson tracks, which are also of much greater interest.

This project was financed by the Royal Society Paul Instrument Fund, and we are glad to express our indebtedness to the Paul Instrument Fund Committee. We also wish to thank the Research Laboratories of the General Electric Co., Ltd., Wembley, for the loan of the special magnetron, and Messrs. Willshaw, Stainsby and Cooper for instructing us in the use of this device. Our thanks are due also to Prof. J. G. Wilson for much encouragement and advice in cloud-chamber techniques.

EFFECTS OF OXYGEN UPON LIGHT ABSORPTION BY GREEN ALGAE

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IN spectroscopic studies of the purple bacteria, a correlation between the effects of oxygen and light provides direct information on the nature of the light reaction and assists in identifying the point in the respiratory chain at which photo-produced oxidants may react[1,2]. Many papers have appeared recently describing spectroscopic changes caused by illumination of *Chlorella* and other green cells[3–9], but no dark process has yet been described which produces the same effects as illumination. It has been found that oxygenation of various types of anaerobic green cells causes the appearance of the absorption band at 515 mμ that has already been observed to appear upon illumination with red light. In the region 475–560 mμ the spectroscopic effects of oxygenation and illumination are very similar and these results lead us to suggest that the compound absorbing at 515 mμ results from an oxidation or an analogous excitation of a 'dark' compound absorbing at 475 mμ. The results also afford an explanation of the divergent conclusions of Witt[7].

The double-beam spectrophotometric method is similar to that previously used in studies of purple bacteria[1] and in the photodissociation of the cytochrome a_3 carbon monoxide compounds[10]. In the case of acetate-grown *Chlamydomonas*[3], the respiration was sufficiently rapid for the oxidized-minus-reduced difference spectra to be measured in a cuvette in the manner used for the study of cytochromes. Slowly respiring algae were placed in a moist chamber, the horizontal base of which was very close to the photomultiplier tube. The algae settle on the base of this chamber and form a uniform layer suitable for spectrophotometric observation. The algae were equilibrated with oxygen–carbon dioxide or nitrogen–carbon dioxide mixtures. For red illumination, a Corning 2030 filter was interposed between the algae and the white light and a blue filter (Wratten 44*A*) between the algae and the photocell. Oxygen concentrations were monitored with a platinum electrode.

By alternately oxygenating and de-oxygenating the algal suspension, absorbancy changes are measured with respect to a reference wave-length (usually 495 mμ) and are plotted as illustrated in Fig. 1 for *Chlorella* (supplied by Dr. Ruth Sager) and *Chlamydomonas* (supplied by Mr. L. M. Pakman). Absorbancy increases occurring on oxygenation are plotted as an upward deflexion. The *Chlorella* suspension shows a peak at 516 mμ and the *Chlamydomonas* suspension, in which the range 490–648 mμ is covered, show a similar peak at 515 mμ, a shoulder at 530 mμ and a trough at 550 mμ, with no other large changes out to 648 mμ.

It is possible to identify which phase of the various reactions that follow illumination of the anaerobic algae corresponds to the oxidized-minus-reduced spectrum. In Fig. 2, we have recorded the reactions

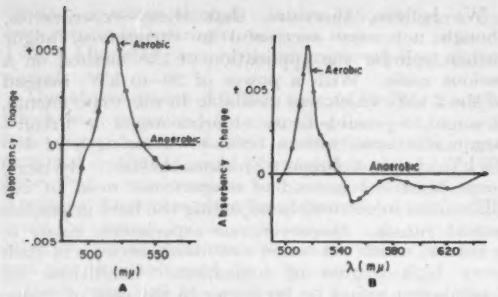

Fig. 1. Anaerobic minus aerobic difference spectrum for *Chlorella* (*A*) and for *Chlamydomonas* (*B*). The absorbancy changes were measured with respect to 495 mμ as described in the text. Absorbancy increases occur on oxygenation of the anaerobic algae

following red illumination. The *Chlorella*, initially anaerobic, are illuminated for about two minutes. During this interval there is an abrupt increase of absorbancy at 502 mμ and at 522 mμ, measured with respect to 495 mμ. This abrupt increase is followed by a small, slow decrease of absorbancy (phase 1) which in separate experiments is found to be caused by a decrease in the light-sensitivity with time. On cessation of illumination, a small but abrupt decrease of absorbancy occurs, the transition from illuminated to dark aerobic cells (phase 2). During the next ten minutes a slow change of absorbancy occurs (phase 3). This is caused by dis-oxygenation of the cells by dark respiration. A repetition of these experiments at a variety of wave-lengths gives a difference spectrum for the phase 3 transition which agrees with that of Fig. 1 to within the experimental error. This decrease of absorbancy recorded in phase 3 is the major part of the absorbancy change caused by illumination, and can be caused by either added oxygen or by photo-produced oxygen or other oxidants. Since the specificity of molecular oxygen in biological oxidations is well recognized, it is proposed that the appearance of the absorbancy band at 515 mμ in the phase 3 transition is an oxidation and its disappearance represents a reduction.

In the spectra published by other workers in this field on the effect of illumination, none has specified whether the results were obtained under aerobic or anaerobic conditions, although Duysens has noted that the effect at 515 mμ was enhanced by anaerobiosis[3]. However, we can identify the state of aerobiosis of the various preceding papers from the kinetics of the reactions following cessation of illumination. If the effects are rapid, as in the case of Witt[7] and Kok[8], the phase 2 transition was probably measured (reaction D[11]). If the effects are slow, as they must have been in the case of Lundegårdh who used roughly half a minute to scan the spectrum[5], the effects may be attributed to the phase 3 transition. Strehler and Lynch[6], who describe a 'negative overshoot' phenomenon, showed the phase 1 effect in their kinetic records and may have measured a spectrum corresponding to phase 2.

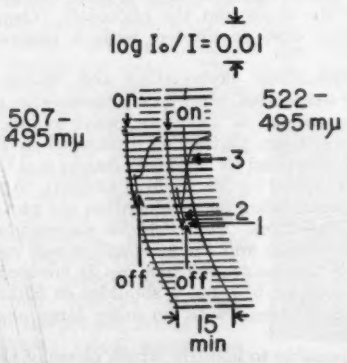

Fig. 2. Sample records showing at two wave-lengths the kinetics of the absorbancy changes that occur upon illumination of anaerobic *Chlorella* and upon cessation of illumination, after a light-interval of about two minutes

Witt has concluded that the increased absorbancy at 515 mμ that he observed, here identified as the phase 2 transition, represents a reduction[7], while the considerations given above lead us to the conclusion that the phase 3 increase of absorbancy corresponds to an oxidation. Since the phase 3 and phase 2 transitions are found to have similar difference spectra, the inconsistency of the two conclusions is obvious. Witt, however, was unable to cause the phase 2 transition to occur by the addition of reductant and based his conclusions only upon the observation that the phase 2 effect in spinach chloroplasts disappeared more rapidly in the presence of one Hill oxidant (2-6-dichlorophenolindophenol, although no appreciable effect was caused by others (ferricyanide, quinone[11]). Since we have shown the phase 3 effect to be caused by one of the most specific biological oxidants, molecular oxygen, we prefer the explanation that both the phase 2 and phase 3 transitions represent oxidations upon illumination and reductions upon cessation of illumination. It is further proposed that the phase 2 transition represents an increase in the steady-state oxidation-level beyond that obtainable by oxygen; but in this case the oxidation is opposed by a highly reactive photo-produced reductant which is responsible for the rapid disappearance of the phase 2 effect upon cessation of illumination. In cases where a temporary excess of reductant over oxidant occurs, negative overshoot phenomena such as those described by Strehler and Lynch[6] can be accounted for.

In summary, the pigment appearing at 515 mμ upon illumination of green cells is concluded to be an oxidation-reduction indicator responsive to intracellular generation of oxidants and reductants produced in photosynthesis. Its identification with the primary process of photosynthesis[11] cannot be accepted until the nature of the pigment has been elucidated and its apparent absence in *Porphyridium*[4] and in a photosynthetic mutant of *Chlamydomonas*[12] can be accounted for.

This investigation was supported in part by the National Science Foundation.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Longitudinal Polarization of the Positrons from the Decay of Unpolarized Positive Muons

It is now well known that parity is not conserved in weak Fermi interactions, and that this generally results in longitudinal polarization of the spins of the emitted particles. Very strong polarizations of the muons emitted in pion decay[1], and of the electrons emitted in beta decay[2], have already been detected. The experiment reported here was aimed at detecting longitudinal polarization of the positrons emitted in the decay of unpolarized muons.

The strength of the various effects leading to non-conservation of parity observed so far has led to the hypothesis of a specially simple theoretical scheme, the two-component neutrino theory with lepton conservation[3]. If the beta-decay interaction is taken as being a scalar and tensor mixture, this scheme leads to the prediction that the positrons from positive muon decay should be predominantly 'left-handed', that is, that the spins of the positrons should point in the opposite direction to their direction of motion. A determination of the positron polarization thus offers a direct test of the theory.

We have determined the sign of the polarization experimentally by a method first applied by Goldhaber, Grodzins and Sunyar[4] to the decay electrons from strontium-90, and by Lederman[5], though with as yet inconclusive results, to the muon decay electrons.

The positive pion beam of the Liverpool synchro-cyclotron was brought to rest in a 2-in. thick carbon target which then became a source of positrons produced in the π–μ–e decay sequence. Some of these positrons passed through two scintillation counters into a lead plate in which they produced bremsstrahlung quanta. These quanta have been shown by McVoy and Dyson[6] to retain a large fraction of the polarization of the incident electrons.

The quanta passed through a cylinder of iron 6 in. long which could be magnetized axially in a direction parallel or anti-parallel to the direction of motion of the quanta. They were then detected by a $4\frac{1}{2}$-in. diameter crystal of sodium iodide. The total cross-section for Compton scattering is smaller, in our energy-range, when the spins of quanta and scattering electron are parallel than when they are anti-parallel, and the experiment compared the transmission of the quanta through the iron in the alternative states of magnetization.

The required pulses from the sodium iodide detector were selected by forming a fast triple coincidence with the two positron counters and using this to gate the pulses linearly to a pulse-height analyser. A counter telescope in the pion beam served as monitor, the direction of magnetization being reversed after a certain number of monitor counts, chosen to give intervals of about 1 hr. between reversals.

Great care was taken to screen the photo-electron multipliers from the stray magnetic field, and extensive checks were made to confirm that reversal of the field did not affect the sensitivity of any of the counters. An overall check was made using the unpolarized fast electron contamination of the negative pion beam instead of the muon decay positrons. Finally, to show that the arrangement behaved as expected with polarized electrons, the experiment of Goldhaber *et al.* with strontium-90 was repeated and the same result obtained.

Two runs of five days duration were made with the muon decay positrons and the combined results are displayed in Fig. 1. Here we have plotted the difference between the pulse spectra from the sodium iodide detector for the two directions of magnetization as a percentage of the mean. The errors shown are the statistical standard deviations. A rough estimate has been made of the expected form of this plot on the basis of formulæ given by McVoy and Dyson[6] and by Gunst and Page[7], and this is indicated by the broken line. The maximum of the curve should be in the region of 5 per cent if the positrons are fully polarized.

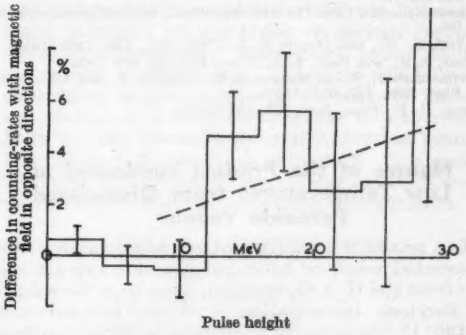

Fig. 1

The results point to a high degree of longitudinal polarization of the muon decay positrons. The transmission of the iron core was greater when the north pole was towards the positron source, showing that the positrons were predominantly 'right-handed', having their spins pointing in the direction of motion. The statistical significance of the result can be demonstrated by combining all the measurements on pulses greater than 12 MeV., when we have a difference of $4{\cdot}54 \pm 1{\cdot}18$ per cent. The probability that the difference is really zero is then 1 in 17,000.

Thus the result of the experiment is contrary to the prediction of the two-component theory with lepton conservation. However, it appears that the scheme can be saved if the beta-decay interaction has been wrongly identified[8] (that is, if the interaction is vector and axial vector rather than scalar and tensor, and the leptonic signs of neutrino and anti-neutrino are reversed). We intend to carry out the analogous experiment with electrons from the decay of unpolarized negative muons. On very general grounds[8], the polarization should be equal in magnitude to the positron polarization but opposite in sign.

We wish to record our thanks to Prof. H. W. B. Skinner for the close interest he has taken in this work, and to Prof. J. M. Cassels and Dr. H. Uberall for valuable discussions. The work with the cyclotron was greatly facilitated by the co-operation of the operating crew under Mr. B. Halliday. Two of us (G. C. and T. M.) acknowledge the receipt of grants

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Sept. 18.

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Nature of the Product condensed at Low Temperatures from Dissociated Peroxide Vapour

The products condensed at low temperatures from dissociated water or hydrogen peroxide vapour, and also from the H + O_2 reaction, have been the subject of frequent investigation. When warmed near − 120° C., these products invariably transform from glassy to crystalline deposits, simultaneously evolving oxygen, and at room temperature water and hydrogen peroxide remain. The hypothesis, however, that this behaviour arises from the existence of an isomer of hydrogen peroxide[1] or an equivalent 'complex'[2,3] stable only at low temperatures has recently lost ground in favour of one based on the existence of trapped radicals[4–6] in the matrix of amorphous ice.

We have recently investigated the dissociation of pure hydrogen peroxide vapour in an a.c. discharge, and a study of the condensed product has formed an important part of the work. When the products of the reaction were condensed at − 78°, no peroxide or evolved oxygen was detected on warming, and the residue was pure water. Hydrogen peroxide and evolved oxygen (mass spectrometric analysis confirmed that no hydrogen was present), however, were always obtained from deposits condensed at − 183° or − 195°, the yields increasing as the trap temperature was changed from − 183° to − 195°, and decreasing as the distance between discharge and trap was increased (cf. ref. 3). The influence of current and rate of hydrogen peroxide input on the condensed and uncondensed products was also systematically studied. Variations designed to increase the concentration of radicals issuing from the discharge led also to increases in the amounts of hydrogen peroxide and evolved oxygen, but their ratio was little affected.

The above characteristics confirm that the condensed substance produced in our studies is entirely analogous to those obtained in the work already cited. Further information on the temperature and rate at which oxygen was evolved was therefore sought, since it is this aspect which has hitherto received least attention. In agreement with others, preliminary studies showed that, irrespective of the quantities of products, major evolution was first observed near − 120°. Using constant-temperature baths, the rate of evolution from a standardized deposit was then studied in separate experiments (Fig. 1). Extremely small, but quite definite, quantities of oxygen were produced at − 137° and − 123°. By − 115°, however, the major evolution process was already much in evidence. The results collected in Fig. 1 emphasize the suddenness of its onset. Taken together with the experiment at − 123°, the warming delay before evolution in experiments at − 115° and − 108° indicates a critical temperature for evolution very close to − 120°.

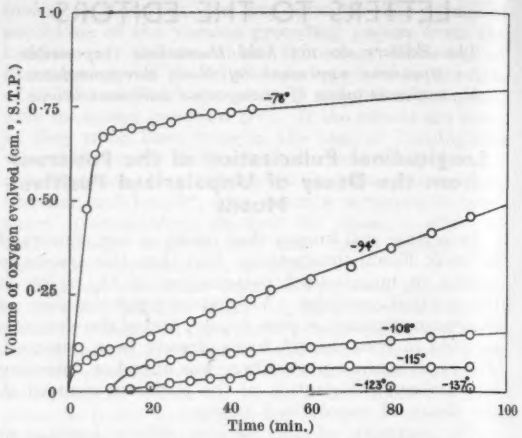

Fig. 1. Rate of evolution of oxygen from the condensed product at various temperatures. In each case the product was formed at − 195° in 1 hr. at the same current and flow-rate. The 'total evolved oxygen' from each deposit (20° C.) was 1·4 cm.³, stp. The zero of time corresponds to the instant at which the − 195° bath was replaced by the warmer bath

We suggest that for the real significance of this 'chemically derived' critical temperature one should look to recent studies of the physical structure of condensed water vapour. Ghormley[7], and more particularly Blackman and Lisgarten[8], have shown that amorphous ice undergoes a sharp transition to a cubic form at − 120°. It is felt that, of the two hypotheses mentioned, that which postulates recombination of trapped radicals is more in line with initiation by a solid transition. During the formation of the deposit, one may suppose that OH and HO_2 radicals[9,10] present in the stream issuing from the discharge become first adsorbed and then incorporated in the amorphous ice as the deposit builds up. The radicals form hydrogen bonds, so that below − 120° they are almost certainly immobile in the bulk of the deposit. At − 120°, the re-ordering of the hydrogen bonding which accompanies the crystallization renders a fraction of the radicals mobile for bimolecular reactions, for example:

$$OH + HO_2 = H_2O + O_2$$
$$OH + OH = H_2O_2$$
$$HO_2 + HO_2 = H_2O_2 + O_2$$

Oxygen probably diffuses out of the condensed product along grain boundaries. The adsorption step (*q.v.*) is considered important: the increased

residence time at lower substrate temperatures is probably partly responsible for the increased yields of hydrogen peroxide and oxygen evolved found under those conditions. Moreover, selectivity at this stage may be an influence underlying the ratio of peroxide to evolved oxygen.

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Anion Exchange Behaviour of Yttrium

In a recent paper[1], we have reported the uptake of thorium on a strong-base anion exchange resin from sulphate and carbonate solutions. It was also observed in this laboratory that a trace amount of yttrium-90 was adsorbed on such resin from ammonium sulphate, sulphuric acid and sodium carbonate solutions.

The resin employed was 'Dowex 1×-8', consisting of 100–200 mesh beads. Before use, it was converted to the sulphate or carbonate form and then stored in a desiccator over a saturated solution of sodium bromide. Columns of 8-mm. diameter filled with 3 gm. of the resin were prepared. Yttrium-90 tracer, supplied as hydrochloric acid solution, was evaporated almost to dryness on a water-bath and dissolved in solutions of ammonium sulphate, sulphuric acid and sodium carbonate of various concentrations. For the measurements of radioactivities, the samples were prepared as follows: for column studies, one drop of the effluent was evaporated on a glass disk under an infra-red lamp, while, for equilibrium studies, yttrium-90 in the solution equilibrated with resin was coprecipitated with 5 mgm. of ferric iron and the radioactivity of the dried precipitate was noted.

Only column studies were carried out for ammonium sulphate and sulphuric acid solutions. The resin columns were first treated with simple ammonium sulphate or sulphuric acid solutions of certain concentrations. Then a 0·1 ml.-portion of yttrium-90 tracer solution was placed on the top of each column. The elution was carried out with ammonium sulphate or sulphuric acid solution at a rate of 0·3 ml. per minute.

From the elution curves obtained, the distribution coefficients were evaluated by the relationship,

$$V = I + M \times K_d$$

where V is volume of effluent necessary to obtain the eluted yttrium in maximum concentration in the effluent, I is the fractional interstitial space, M is total amount of resin and K_d is the distribution coefficient (radioactivity per gm. resin/radioactivity per ml. solution). The values of K_d are shown in Table 1.

Table 1. K_d Values for Sulphuric Acid and Ammonium Sulphate Solutions

Solution	K_d
1 *M* Ammonium sulphate	~ 1
0·1 *M* Ammonium sulphate	~ 3·5
0·01 *M* Ammonium sulphate	~ 3
0·1 *M* Sulphuric acid	< 1
0·01 *M* Sulphuric acid	~ 1·5

Experiments were carried out at room temperature

Both column and equilibrium studies were carried out for carbonate solutions.

After the resin bed was treated with 0·1 *M* sodium carbonate solution, 10 ml. yttrium-90 solution was added to the top of the column. Then the column was washed with 20 ml. of 0·1 *M* sodium carbonate solution. No activity of yttrium-90 was detected in the effluent.

The adsorption of yttrium-90 from 1 *M* sodium carbonate solution was rather weak so that a K_d of 6 was obtained by the column method as described above.

A weighed portion of the resin was allowed to stand overnight in a solution of sodium carbonate under consideration. Yttrium-90 tracer solution was added to the system. After the whole system was placed in glass-stoppered Erlenmeyer flasks, it was shaken on a mechanical shaker in a thermostat at 25° C. until the exchange equilibrium was attained. The values of K_d are given in Table 2. It is remarkable that the adsorbability of yttrium-90 increases rapidly with decreasing carbonate concentration.

Table 2. K_d Values for Sodium Carbonate Solutions (at 25° C.)

Solution	K_d
1 *M* Sodium carbonate	~ 6*
0·67 *M* Sodium carbonate	~ 20
0·34 *M* Sodium carbonate	~ 100
0·1 *M* Sodium carbonate	~ 3,000
0·01 *M* Sodium carbonate	~ 104

* This value was obtained by the column method at room temperature

Details will be published elsewhere.

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A New Compound of Univalent Cobalt

Polarographic behaviour of the ions $Co(dipy)_3^{3+}$ and $Co(dipy)_3^{2+}$ shows that they are reversibly reduced at the dropping mercury electrode to a compound of univalent cobalt which does not decompose in neutral aqueous or ethanolic solutions.

The redox potential, measured as half-wave potential, of the Co^{I}—Co^{II} couple in the complex with dipyridyl was found to be − 0·91 V. (vs. aqueous saturated calomel electrode) in a 1 *M* lithium chloride ethanolic solution and − 1·24 V. (vs. saturated calomel electrode) in aqueous solution.

As the polarographic behaviour of the Co^{I}—Co^{II} couple suggested that the complex of univalent cobalt with dipyridyl is stable in the solution, attempts were made to carry out the reduction in the solution and to isolate the complex.

As the starting compound, $Co(dipy)_3(ClO_4)_3 . 3H_2O$ (prepared according to Burstall and Nyholm[1]) was

chosen. From among many reducing agents studied, sodium borohydride proved to be the most suitable. To a suspension of $Co(dipy)_3(ClO_4)_3.3H_2O$ in a water–ethanol mixture (1 : 3) an aqueous solution of sodium borohydride was slowly added. The reduction took place immediately, forming a deep blue solution. A portion of the solvent was then slowly distilled off *in vacuo* at ordinary temperature. Very fine dark blue crystals separated during this operation. The crystals were filtered off, washed with a small amount of water and dried *in vacuo*. All these operations had to be carried out in an inert atmosphere, because the product is highly sensitive to oxidation.

Preliminary analysis showed that the dried compound has the composition $Co(dipy)_2ClO_4$. The compound is slightly soluble in water and much more so in ethanol, giving a deep blue solution. The solutions in ethanol are relatively stable in the absence of oxygen. The solid, perfectly dry compound is stable in an atmosphere of nitrogen. The diffusion coefficient of the blue Co^{I}-complex is about 30 per cent greater than that of $Co(dipy)_3^{2+}$, showing, in accordance with analysis, that the particle is smaller.

The valency of cobalt in this compound was determined polarographically. The blue compound is anodically oxidized at the dropping mercury electrode at the same potential at which the ion $Co(dipy)_3^{2+}$ is reduced (see Fig. 1); the height as well as the shape of the wave correspond to a one-electron process, showing that the compound contains univalent cobalt. The oxidation product of the ion $Co(dipy)_3^{+}$ in the presence of excess of dipyridyl is the ion $Co(dipy)_3^{2+}$. The same product is obtained also by oxidation with oxygen. Furthermore, during the electrolytic reduction of $Co(dipy)_3^{2+}$ a deep blue colour is observed at the electrode surface, indicating that the product of the one-electron reduction of $Co(dipy)_3^{2+}$ is identical with the compound isolated.

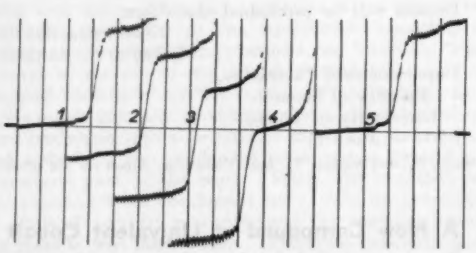

Fig. 1. Reduction of $Co(dipy)_3^{2+}$ with sodium borohydride. Curve 1: 0·07 *M*-dipyridyl in ethanol saturated with lithium chloride, 1×10^{-3} *M* Co^{II}. Curves 2–4: Stepwise reduction with aqueous solution of sodium borohydride. Curve 5: Solution 4 after oxidation with air. From −0·2 V. (saturated calomel electrode); 200 mV. (absc.); nitrogen atm.; $S = 1 : 50$

It was not possible to decide whether the univalent complex ion is diamagnetic or paramagnetic, since contamination by Co^{II} caused much uncertainty in the magnetic measurements. However, from the polarographic behaviour, it is expected that the compound has no unpaired electron.

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Softening of Steels by Cold-Working

A phenomenon of softening in quenched and tempered steel subjected to small amounts of deformation has been reported by Armour[1] and by Wilson[2]. Other workers had also observed that the hardness of sorbitic and troostitic steels remained constant during the early stages of cold-working[3,4].

Based on similar softening effects observed after deformation of metals previously cold-worked in the opposite direction, Polakowski[5] formulated a general rule stating that work-softening would take place whenever the method of deformation used would produce an internal stress system different from that left after the preceding treatment, be it mechanical or thermal in nature. Later, Wilson[2] attempted to explain the mechanism of work-softening on the basis of dislocations. By determining the strains on cementite particles by means of X-ray and Curie temperature measurements, Wilson had previously shown[6,7] that the textural stresses set up between the ferrite and cementite as a result of cold-working may be quite high. Such a textural stress system, which is present in quenched and tempered steels, may be greatly modified as a result of plastic deformation by being, for example, changed from an isotropic to an oriented system. Indentation hardness tests may indicate softening or very low rates of work-hardening during this process, but the extent of the effect appears to be influenced by the scale of the internal stress pattern as well as the magnitude of the initial textural stresses. This is discussed more fully by Wilson in ref. 8.

This effect was recently observed in these laboratories during the course of an investigation on the rifling by cold-forming of small-calibre gun barrels. Some work was thereafter initiated to study the effects of steel composition on work-softening, and it is felt that some early results might be of interest.

The testing method used is very rapid. Rough machined specimens of the steels are quenched and tempered according to normal procedure for these steels. Flat-tapered tensile specimens are then finish-machined and fine lines scribed every 2 mm. on one of the large faces. The whole range of strains is thus obtained in one single pull test. The strains are determined by measuring the distance between the scribed lines after deformation. The Vickers hardness is determined at the centre of the areas enclosed by the scribed lines.

Three steels have been used so far: *AISI* 4340, 'Hy-Tuf' and Type 420 stainless steel. The compositions are given in Table 1.

An alloy steel (*AISI* 4340) was first chosen, to compare results with those obtained previously[2] on a carbon steel. The second steel was chosen mainly because of its high silicon content and of the effects of silicon in retarding the precipitation of carbides during tempering. It was thought that this could affect the work-softening phenomenon at various temperatures. Finally, Type 420 stainless steel was

Table 1

	C %	Mn %	Si %	Cr %	Ni %	Mo %
AISI–4340	0·38–0·43	0·60–0·80	0·20–0·35	0·70–0·90	1·65–2·00	0·20–0·30
'Hy-Tuf'	0·25	1·30	1·50	—	1·80	0·40
Type 420 Stainless	0·30	1·25	—	13	—	—

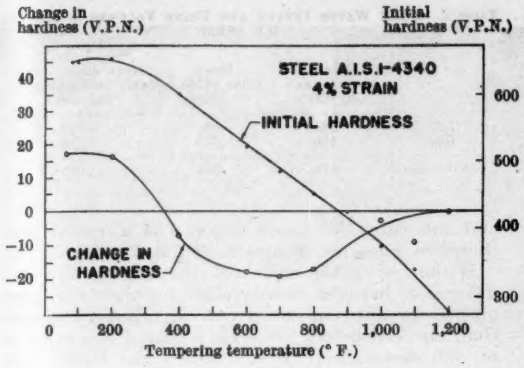

Fig. 1

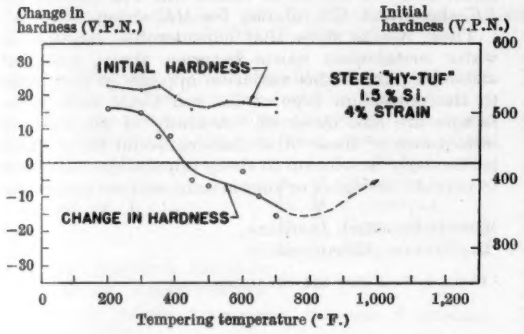

Fig. 2

included because it shows a strong secondary hardening phenomenon. In this way the same hardness can be obtained after three different tempering temperatures, that is, possibly under three different stress systems, and it was thought that the results would be instructive.

In the three steels tested, tempering temperatures below 300–400° F. produced no work-softening. On the contrary, work-hardening was obtained although, on the basis of internal stresses alone, a severe work-softening effect should be expected. Polakowski has recently proposed[9] that a concomitant phenomenon may be taking place during the deformation of martensite, namely, an extremely high strain-hardening rate of the martensite, that would mask the softening effect.

The first point of zero change in hardness occurs at a slightly higher temperature in 'Hy-Tuf' than in 4340 (Figs. 1 and 2), while the temperature of maximum softening probably remains approximately the same, that is, 700° F. (370° C.). The amount of work-softening seems to be slightly less in 'Hy-Tuf', and this may be due to the retardation in softening during tempering.

Type 420 stainless steel, on the contrary, shows no work-softening at all (Fig. 3). At equal hardnesses, obtained after tempering at 500, 675 and 875° F., no work-softening was observed and no difference in behaviour was obtained in spite of the difference in the internal stress systems present after the three different treatments.

In view of these latter results, it seems that the generally observed effect of softening in quenched and tempered steels after deformation may not be a function of the presence of internal stresses only, as has been believed previously, but that a concurrently active phenomenon is taking place to mask the work-softening effect. This may be a precipitation mechanism, and it is hoped that future work along these lines, including the determination of distribution and size of carbide particles in these steels and the correlation of work-hardening coefficients with amounts of retained austenite, will prove fruitful.

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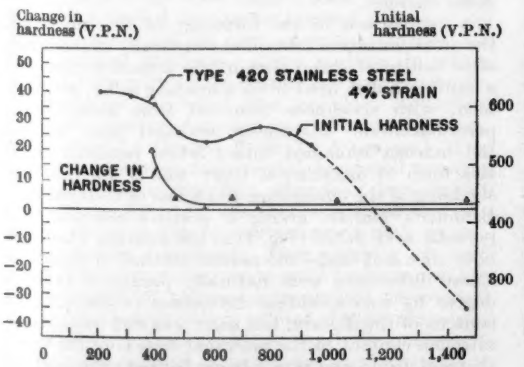

Fig. 3

Structure of the Crust under the Eastern Mediterranean Sea

The recent disastrous shocks in southern Turkey (April 24, 1957, 19–10–05, 36° N., 28·5° E., and April 25, 1957, 02–25–36, 36·5° N., 29° E.) produced very strong *Lg* and *Rg* waves on the Benioff vertical seismometer at Lwiro (2° 15′ S., 28° 48′ E.). The shock of July 9, 1956, 03–11–39, 37° N., 26° E., also produced very strong *Lg* waves.

Because of the very short periods (about 1·5 sec.) and the gradual build-up of amplitudes, the times of arrival of *Lg* on the short-period (0·25 sec.) galvanometer (*Z*) are up to 60 sec. earlier than those on the long-period (25 sec.) one (*X*). *Rg* is only clear on *Z* and for the shock of April 25, 1957.

The velocities are: for *Lg*, on *Z*: 3·65 ± 0·04 km./sec.; on *X*: 3·53 ± 0·02 km./sec.; for *Rg*, on *Z*: 3·29 km./sec.

This is the first time that these waves have been identified after a fairly long submarine path. Their large amplitudes on the records of these shocks is in

contrast to their absence or very small amplitudes on records of shocks in Greece.

It is suggested that this indicates a difference between the structure of the bottom of the Mediterranean Sea south of Greece and that south of Turkey. The exact nature of this difference and its important geotectonic implications would appear to make seismic refraction work at sea desirable in these areas.

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Water Metabolism in the Sheep

Some sheep appear to pass consistently lower urine volumes than others, and during metabolism cage experiments with *HK* and *LK*[1] Scottish Blackface sheep there was a suggestion that within each of these two groups there was much more variation between animals than between repeated observations on the same animal, and that, on the whole, urine volumes from *LK* animals tended to be lower than those from *HK* animals. The results of an analysis of the results from fifteen trials involving 19 *LK* and 17 *HK* animals are given below. Four or six animals were used per trial and equal numbers of *LK* and *HK* were used in all except three trials. The animals were in the cages for 10, 20, 32 or 93 days in each trial. A standard ration of hay and concentrates (oats and linseed meal) was fed throughout, and a sodium chloride supplement was given in all except three trials, but this did not have a marked effect on urine output.

The mean volume of urine excreted daily was found to be significantly lower for *LK* than for *HK* sheep ($P < 0{\cdot}01$). The difference can be seen most readily by studying the frequency distribution of the average results for individual sheep (Table 1) and, although there is considerable overlap, the mode for *LK* sheep (approximately 500 ml./day) is clearly lower than that for *HK* sheep (approximately 700 ml./day). In addition there are a number of high values for the *HK* sheep. Because of the skewed nature of the distributions, median values rather than mean values give a more accurate idea of the difference.

The means for the volumes of water consumed and urine excreted daily followed each other closely,

Table 1. Sheep Urine Volumes per Day Frequency Distribution

Range of values (ml./day)	Numbers of sheep *LK*	*HK*
151–250	1	
251–350	2	
351–450	1	1
451–550	8	1
551–650	3	2
651–750	1	5
751–850	1	2
851–950	1	
951–1,050		
1,051–1,250	1	1
1,251–1,450		1
1,451–1,650		
1,651–1,850		2
1,851–2,050		
Over 2,050		2
Median value (ml./day)	524	734

Table 2. Mean Water Intake and Urine Volumes in *LK* and *HK* Sheep

	Mean water intake (ml./day)	Mean urine volume (ml./day)	Mean fæces water and insensible loss (ml./day)
LK	1,845	552	1,293
HK	2,459	1,073	1,386
Difference	614	521	93

and the value for fæces water plus insensible loss therefore remained constant (Table 2).

Within both the *LK* and the *HK* groups, the differences between mean values for the daily urine output for different sheep were significantly greater than the differences between repeated observations on the same sheep ($P < 0{\cdot}001$). For those sheep which spent three separate periods in the cages, the mean range of the three values was 173 ml./day for *LK* sheep and 478 ml./day for *HK* sheep.

These results show that considerable variation in water metabolism exists between sheep, and that although part of this variation appears to be related to the potassium type of the red blood cells, other factors are also involved. A study of the mode of inheritance of these other factors would be of value particularly in relation to sheep populations subjected to periodic droughts or kept in semi-arid environments.

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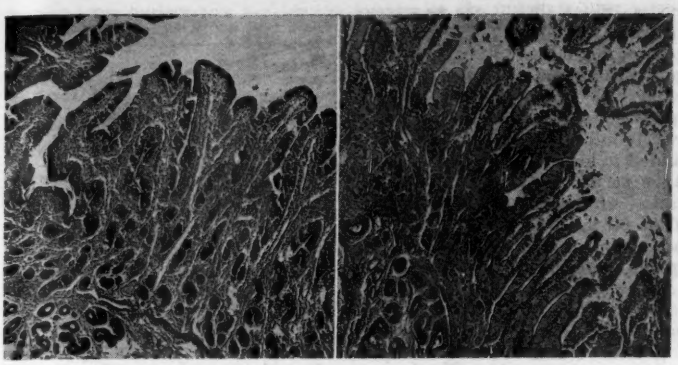
Changes in the Intestinal Mucosa of the Sheep following Death by Humane Killer

In the course of an investigation of the changes in composition of the digesta along the alimentary tract of the sheep[1], it was noted that there was a considerable addition of nitrogen to the chyme in the most proximal quarter of the small intestine. The nitrogen content in the remaining quarters fell off distally until the abomasal level was attained in the fourth quarter. It was noted from *in vivo* studies on fistulated animals, and in those with exteriorized loops of the small intestine within the first two feet or so of the pylorus, that this addition of nitrogen did not occur to the same extent as in the shot sheep. Lignin was used as a reference substance to assess these changes.

A comparison of the histology of the mucosa of the small intestine (obtained practically immediately after death) of sheep shot in the frontal region with a captive bullet fired from a humane killer, and then bled, with specimens removed from sheep under pentobarbitone anæsthesia revealed that whereas the mucosa remained intact when removed under this form of anæsthesia, there was a very marked shedding of the epithelium and a loss of material from Brunner's glands, giving a positive reaction with periodic acid–Schiff (Fig. 1) in the animals which had been shot and bled—the normal method of slaughter. These differences were naturally paralleled to some degree by corresponding differences in the nitrogen content of the digesta, but there was still some rise in nitrogen content in the proximal section of the anæsthetized group and this is being further examined. It was thought advisable to bring to the attention of all those who work on the intestinal wall and on intestinal



a *b*

Fig. 1. Section of duodenum. Periodic acid–Schiff hæmalum (× 33). *a*, sheep anæsthetized; *b*, sheep shot and bled

contents this very marked shedding of the epithelium —mainly in the first quarter—and its elimination by removing the specimens under pentobarbitone anæsthesia. This finding has also been confirmed in the rat.

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Contamination of Stock Lines of Human Carcinoma Cells by Pleuropneumonia-like Organisms

During January and February 1957 it was noticed that a line of human carcinoma cells (strain HeLa[1]) maintained in this laboratory was not growing normally. The cells failed to form continuous sheets on the glass surfaces of the culture bottles, and after 10–14 days growth the cultures had macroscopic 'moth-eaten' areas at the edges in which the cells were rounded and degenerate. The tissue culture medium was 80 per cent Eagle's basal medium[2] and 20 per cent pooled human serum, and contained 80 units penicillin and 80 μgm. streptomycin per ml. When samples of tissue culture medium in which cells had been grown were seeded into nutrient broth, faint turbidity developed after two days incubation at 37°, but no micro-organisms were found in preparations stained by Gram's method. 5 per cent horse blood agar plates similarly seeded developed colonies, 0·5 mm. or less in diameter, after four days aerobic incubation at 37°. It was then suspected that the tissue cultures might be contaminated with pleuropneumonia-like organisms; when samples of used culture fluid were seeded on to solid medium suitable for the growth of pleuropneumonia-like organisms[3], colonies with a morphology typical of these organisms grew after three days aerobic or anaerobic incubation at 37°. The colonial appearances were maintained during repeated subculture on this medium, in the absence of penicillin and thallium acetate. The organisms could not be isolated from fresh tissue-culture medium. Successive HeLa cell subcultures yielded profuse growths of pleuropneumonia-like organisms which seemed to multiply in association with the cells, since it has been shown that the organisms do not survive for more than 2 or 3 days in the tissue culture medium employed (Blyth, W., unpublished observations).

HeLa cell cultures from other laboratories were tested for pleuropneumonia-like organisms (Table 1). All these lines originated directly or indirectly from Laboratory *A*, which received the cells from Dr. Syverton in 1953. Of eight sublines of cells maintained in Laboratory *A*, only one (here referred to as *A*8) was free from contamination, and this had been maintained separately from the others by one worker. It is also noteworthy that the three lines of cells from which pleuropneumonia-like organisms could not be isolated (Line *A*8, and those from Laboratories *E* and *F*) had all at some time been propagated in the presence of aureomycin, terramycin or neomycin. It is known that pleuropneumonia-like organisms are markedly sensitive to antibiotics of the tetracycline group[4,5]. At Laboratory *F*, the cells were always grown in the presence of neomycin, 50 μgm./ml. A culture of this line, adapted to grow in horse and rabbit serum, was returned to Laboratory *A* in January 1957, and was then propagated without neomycin for some months. On examination it was found to be contaminated (Line *A*3). It is not yet clear whether this is due to a fresh contamination, or to unmasking of a latent infection by withdrawal of neomycin.

Strains of pleuropneumonia-like organisms isolated respectively from HeLa cells grown at the Lister Institute, Laboratory *A* and Laboratory *B*, were shown by complement fixation tests to be antigenically similar to strains of pleuropneumonia-like organisms isolated from human genital infections. As with the human genital strains, there were some cross-reactions with antisera to a strain of organisms isolated from a rat, to a saprophytic strain (Laidlaw *A*) and to the organism of pleuropneumonia of cattle, but the titres were much lower than those of the homologous antigens.

It therefore appears that stock lines of HeLa cells are liable to contamination by pleuropneumonia-like organisms. In the United States, Robinson, Wichelhausen and Roizman[5] showed that three out of five lines of HeLa cells, and a line of human conjunctival cells, were similarly contaminated. They suggested that contamination was probably introduced through

Table 1. Isolation of Pleuropneumonia-like Organisms from Lines of HeLa Cells maintained in Various Laboratories

Laboratory	Cell line derived from	Cell lines contaminated/ cell lines tested
A	Syverton, 1953	7/8
B	Lab. *A*, 1955	1/1
C	Lab. *A*, 1956	1/1
D	Lister Institute, 1957	1/1
E	Lab. *A*, 1954	0/1
F	Indirectly from Lab. *A*, 1955	0/1
Lister Institute	Lab. *B*, 1956	1/1

some common constituent of culture media. Since all the cell lines tested have been grown at some time in the presence of human serum, this component might be responsible, although line *A*3 was not grown in human serum at Laboratory *A* between its arrival from Laboratory *F* and isolation of pleuropneumonia-like organisms two months later. I have found that when a large number of organisms are added to human serum, a few organisms survive heating at 55° for 1 hr., so that the customary inactivation of serum by heating at this temperature for 30 or 60 min. is not a certain safeguard against contamination. An alternative hypothesis is that pleuropneumonia-like organisms were present in this cell strain when it was originally isolated from a carcinoma of the cervix. Pleuropneumonia-like organisms occur with moderate frequency in the female genital tract, particularly when disease is present[6].

The relationship between the morphological changes in the Lister Institute HeLa cells and the presence of pleuropneumonia-like organisms is being investigated; Laboratory *C* reports similar changes, but these have not been observed in other laboratories maintaining infected cell lines.

I wish to thank Miss Dorothy Card for the complement fixation tests, and Mrs. E. Klieneberger-Nobel for her interest and advice. I am also greatly indebted to the workers in the various laboratories who provided me with cultures of HeLa cells, and with much helpful information about them.

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Evidence of a Second Fœtal Hæmoglobin in the Newborn Goat

Recently, some reports have appeared suggesting the existence of an embryonic human hæmoglobin which shows slight differences as compared with the fœtal hæmoglobin of the newborn child. Using an alkali denaturation technique, Drescher and Künzer[1] and Allison[2], for example, obtained evidence that the hæmoglobin present in early fœtal life is different from the fœtal and adult hæmoglobin types. Recent investigations of Halbrecht and Klibanski[3] have shown the existence of an embryonic human hæmoglobin which migrates more slowly in paper electrophoresis than the fœtal hæmoglobin from the cord blood of a newborn child. Studying the problem of fœtal hæmoglobin in newborn goats we obtained evidence that in this animal also two different fœtal hæmoglobins occur, which, however, are still present after birth.

Using an alkali denaturation method[4], it was found that the hæmoglobin of the newborn goat consists of two different components, one with a low resistance against alkali and a second with a much higher resistance against alkali (Fig. 1). As the hæmoglobin with low alkali resistance disappears slowly after birth

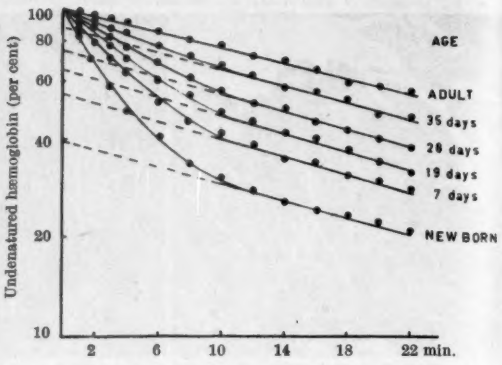

Fig. 1. The alkali-denaturation curves of the hæmoglobins of a newborn goat at different times after birth and of an adult goat

(Fig. 1), while in the blood of the adult goat only the alkali-resistant component is present (Fig. 1), it is obvious that the hæmoglobin of low alkali resistance is of fœtal origin. About 60 per cent of this fœtal hæmoglobin was found present in a goat one day old.

With moving-boundary electrophoresis, paper electrophoresis in a 0·06 *M* barbital buffer *p*H 8·6 and also with chromatography on 'Amberlite *IRC*50'[5], however, the hæmoglobin of the newborn goat behaves as a single component which moves faster than the hæmoglobin of the adult animal. The results of the moving-boundary electrophoresis are given in Fig. 2; the patterns obtained by paper electrophoresis and by chromatography are of the same kind. A few days after birth a second hæmoglobin was found to appear and has the same mobility as the adult hæmoglobin of the goat. The percentage amount of this component gradually increases with time and is about 90 per cent in a goat five weeks old.

Table 1 shows the analytical results obtained by studying blood samples taken at different times after birth with alkali denaturation and electrophoretic techniques. A comparison of the results of these analyses makes it likely that a second fœtal hæmoglobin is present in the newborn goat, which behaves like the adult component with respect to the alkali resistance and like the fœtal hæmoglobin regarding its electrophoretic and chromatographic behaviour. It will be seen from the quantitative data given in Table 1 that about three weeks after birth no significant amount of this second fœtal hæmoglobin could be demonstrated. The fœtal hæmoglobin with low alkali resistance, however, is still present to about 30 per cent at the same time and

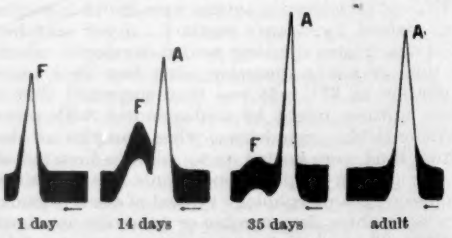

Fig. 2. The moving-boundary electrophoresis of the hæmoglobin of a newborn goat at different times after birth and of an adult goat. 0·5 *M* sodium barbital buffer solution *p*H 8·8. (2½ hr.; 120 volts and 6 amp.)

Table 1. THE QUANTITATIVE DATA OF THE AMOUNTS OF THE DIFFERENT HÆMOGLOBIN TYPES PRESENT IN THE BLOOD OF A NEWBORN GOAT AT DIFFERENT TIMES AFTER BIRTH

Age (in days)	Alkali resistance (per cent)		Moving-boundary electrophoresis (per cent)		Paper electrophoresis (per cent)		Per cent of different hæmoglobins		
	Res.	Non-res.	Slow	Fast	Slow	Fast	A*	F_2†	F_1‡
0	40	60	0	100	0	100	0	40	60
7	55	45			20	80	20	30	45
11	57	43			35	65	35	22	43
14	59	41	48	52	50	50	48§	11	41
19	65	35			60	40	60	5	35
21	68	32	62	38	65	35	62§	6	32
25	70	30			70	30	70	0	30
28	74	26	76	24	75	25	76§	0 (−2)	26
32	85	15			85	15	85	0	15
35	88	12	90	10	85	15	90§	0 (−2)	12
Adult	100	0	100	0	100	0	100	0	0
Kind of Hb estimated	A or $A + F_2$	F_1	A	F_1 or $F_1 + F_2$	A	F_1 or $F_1 + F_2$			

* Hb-A: Alkali-resistant and slow in electrophoresis and chromatography.
† Hb-F_2: Alkali-resistant and fast in electrophoresis and chromatography.
‡ Hb-F_1: Alkali-non-resistant and fast in electrophoresis and chromatography.
§ Calculated from the data obtained by the moving-boundary electrophoresis.

has scarcely disappeared after about six weeks. The relatively fast disappearance of the fœtal hæmoglobins suggests that the survival-time of the erythrocytes of the newborn goat is fairly short. Studying the survival-time of these erythrocytes with chromium-51 and the synthesis of the fœtal hæmoglobins after birth with iron-59, we obtained values for the survival of the red-blood cells of the newborn goat varying between 25 and 30 days (in published work).

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Bacterial Protoplasts from *Bacillus* Species by the Action of Autolytic Enzymes

WHEN certain bacteria are suspended in sucrose solution of suitable concentration and incubated with lysozyme, the rigid cell-walls are dissolved away, leaving relatively stable spherical protoplasts[1]. Lytic enzymes which dissolve the isolated cell-walls of vegetative *Bacillus cereus* have been found in extracts of mechanically disintegrated resting spores[2] and partial autolysates of sporulating cells[3] of this organism. When heat-treated, intact vegetative cells were treated with preparations of these enzymes, the walls were dissolved, leaving the coagulated cell-contents apparently unchanged. It has now been found that when viable organisms are suspended in sucrose solution and treated with these enzymes, relatively stable protoplasts are obtained in good yield.

The method used for the preparation of highly active cell-free solutions of lytic enzymes from sporulating cells of *B. cereus*[3] has been successfully applied to other members of the *Bacillus* group which sporulate readily in suitable liquid medium. For example, washed cells of *B. megaterium*, showing intracellular spore formation at an advanced stage, were suspended in 0·05 *M* citric acid + 0·1 *M* sodium phosphate buffer (*p*H 5·0) at a concentration of about 20 mgm. dry weight/ml. and incubated in the presence of toluene for 2 hr. at 37°. During incubation, vegetative cell material dissolved and free spores were released. A cell-free solution prepared from the autolysate contained lytic enzymes which rapidly dissolved the isolated cell-walls of this organism. Although enzyme preparations from *B. cereus* and *B. megaterium* showed optimum activity against a substrate of cell walls at *p*H values near 4·5 and 7·5, stable protoplasts were more readily obtained from both organisms when they were incubated with the enzyme at *p*H 7–7·5 in the presence of sucrose and cobalt ions. Cultures of the two organisms were grown in tryptic meat broth for 12–18 hr. on a shaker at 37° and the cells were harvested by centrifugation. The bacteria were washed with McIlvaine's buffer (*p*H 7·0) and resuspended in this buffer at a concentration of about 10 mgm. (dry weight) cells/ml. Buffered suspension (0·2 ml.) was mixed with enzyme solution (0·5 ml. derived from about 10 mgm. sporulating cells), cobalt sulphate solution (0·1 ml. ≡ 50 μgm. Co^{2+}), sucrose (50 mgm. ≡ 0·2 mole) and incubated at 37° in parallel with a control suspension without enzyme. After 20–60 min., the rod-shaped bacilli in the enzyme-treated suspension were completely replaced by spherical protoplasts (Fig. 1), whereas no change occurred in the control. Counts made in a Helber 'Hellige' chamber of the protoplasts and bacilli in

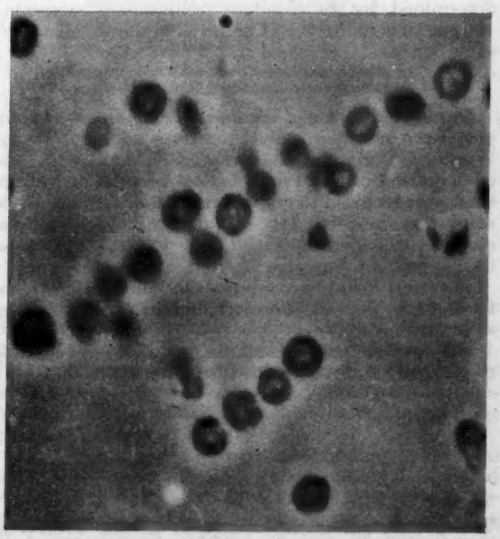

Fig. 1. Protoplasts of *Bacillus cereus*. × 3,000. (A trace of crystal violet was added to the suspension)

the enzyme-treated and control suspensions respectively indicated that recovery of protoplasts was good. Suspensions were stable for at least 24 hr. at room temperature but the structures disintegrated on dilution with water.

Enzymes from sporulating cells of a given *Bacillus* species usually attacked the isolated cell-walls from certain other members of the group but were most active against a substrate of cell-walls from the same organism. For the preparation of protoplasts, autolytic enzymes from sporulating cells of the same organism were used. Such enzymes may prove useful for the preparation of stable protoplasts in cases where the organism is relatively insensitive to the action of lysozyme. Using the conditions described by Weibull[1], we obtained protoplasts in good yield from *B. megaterium*, whereas, using the same concentration of crystalline lysozyme (600 μgm./ml.), the number obtained from *B. cereus* was very small.

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Effects of Gamma-ray Irradiation on Nematodes infesting Cultivated Mushroom Beds

During a discussion with Dr. H. J. M. Bowen, of the Technological Irradiation Group of the United Kingdom Atomic Energy Authority, it was suggested that the effect of gamma-ray irradiation on the nematodes present in compost from infested mushroom beds be determined. Accordingly, 1 cwt. of infested mushroom compost was obtained from a commercial farm, and from representative samples the nematode content, on January 22, 1957, was determined, by the standard technique of extracting 100 gm. of compost for 24 hr. on a Seinhorst 'Mistifier'[1] as :

Ditylenchus destructor	436,000
Saprobes, mostly *Rhabditis* spp.	964,000

Duplicated 200 gm. samples of this infested compost were sealed in polythene bags and sent to the Wantage Radiation Laboratory, where (with the co-operation of the Technological Irradiation Group) they were exposed to gamma radiation from cobalt-60 at a dose-rate of 120 rep/minute. The samples received doses of 6,000, 12,000, 24,000, 48,000 and 96,000 rep, on January 17, 1957.

(A rep—roentgen equivalent physical—is the 93 ergs/gm. deposited on irradiated material, assuming unit density.)

Nematodes in the irradiated compost were counted on January 30, 1957, with the following results :

Treatment	Nematodes/100 gm./24 hr. *D. destructor*	Saprobes
Control	87,000	414,000
12,000 r.	94,500	315,000
24,000 r.	76,500	253,000
48,000 r.	109,500	267,000
96,000 r.	108,500	166,000

The population of *D. destructor*, in the control as well as in the treated samples, has dropped below the pretreatment count. The population of saprobes in the control also fell but with them there was a further continuing diminution with increasing radiation dose.

The work of Fassuliotis and Sparrow[2] suggests that the reproductive capacity is affected by gamma radiation. Assuming this to be so, it appears possible that the fall in numbers of *D. destructor* results from lack of mycelium food material in the compost and not from irradiation, the effects of which are not yet showing because the reproductive cycle of *D. destructor* is relatively long (about 3 weeks). With the saprobes, on the other hand, the reproductive cycle is short (48 hr. for this *Rhabditis* sp.) and, as bacterial food was plentiful, the failure to reproduce may already be showing at the higher doses.

From each sample of irradiated compost nematodes were washed out on an extractor and about a hundred *D. destructor* picked out, then washed with 5 ml. of sterile water into spawn jars filled with sterilized compost, which was inoculated nine days previously with pure culture mushroom mycelium. The inoculated jars were duplicated and kept at laboratory temperature, one series for six weeks, the other for ten weeks.

Examination of the first series after six weeks gave the following results :

	Radiation dose	*D. destructor* in 100 gm./24 hr.
About 100 *D. destructor* inoculated per jar	Control	5,900
	6,000 r.	2,100
	12,000 r.	3,500
	24,000 r.	1,500
	48,000 r.	10
	96,000 r.	2

At this stage the nematodes in the compost receiving the highest two doses were all adults and the females contained no eggs. It appeared, therefore, that nematodes had reproduced in all samples except those receiving the 48,000 and 96,000 r. doses.

After ten weeks the results were :

	Radiation dose	*D. destructor* in 100 gm./24 hr.
About 100 *D. destructor* inoculated per jar	Control	1,070,000
	6,000 r.	388,000
	12,000 r.	2,425,000
	24,000 r.	43,200
	48,000 r.	8,500
	96,000 r.	0

In the meantime other samples of the irradiated compost were extracted and from them two series of twenty *Rhabditis* were hand-picked and cultured, at 25° C., on plates of Nigon's[3] agar sown with yeast. After six days one series of plates was extracted in a Baermann funnel for 24 hr. and the nematodes counted. The results were :

		Radiation dose	*Rhabditis*/plate
20 *Rhabditis* inoculated per plate	*A*	Control	49,500
	B	12,000 r.	14,250
	C	24,000 r.	3,425
	D	48,000 r.	3 alive ; 1 dead
	E	96,000 r.	1 dead

After a further six days the second batch of plates was extracted with the following results :

		Radiation dose	*Rhabditis*/plate
20 *Rhabditis* inoculated per plate	*A*	Control	125,600
	B	12,000 r.	75,750
	C	24,000 r.	41,200
	D	48,000 r.	2,000
	E	96,000 r.	0

The inactivation dose for the two species of nematode examined appears to lie between 48,000 and 96,000 rep, more than twice as great as the 10,000

and 20,000 r. Fassuliotis and Sparrow[2] found to inactivate cysts of potato-root nematode (*Heterodera rostochiensis*).

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Simultaneous Synthesis of Two Inducible Enzymes in *Staphylococcus aureus*

The problem of inducible enzyme synthesis is currently receiving much attention because of its obvious value in the study of protein and nucleic acid formation and their interrelationship[1].

Studies conducted to date have been confined to single systems, and to our knowledge, little is known concerning the effect of one inducible system upon another under conditions favouring simultaneous induction of both. For this reason, we have compared the induction of nitrate reductase and β-galactosidase singly and together in *Staphylococcus aureus*. Nitrate reductase is an inducible enzyme in this organism, and demonstrates many of the characteristics described by Pollock and Wainwright[2] for the *Escherichia coli* system. β-Galactosidase has been shown by Creaser[3] to be an inducible enzyme in *Staphylococcus aureus*.

Induction of both enzymes was carried out according to the method of Creaser[3], with the exception that anaerobic conditions were used throughout. In the presence of 1 per cent galactose, β-galactosidase is formed after a lag period of approximately 30 min. In the presence of 1 per cent potassium nitrate, nitrate reductase is formed rapidly with little or no lag. These results are shown in Fig. 1, where the term 'single' is used for describing induction in the presence of the homologous inducer. The term 'dual' in Fig. 1 refers to the rate of enzyme formation when both inducers are present from zero time. It may be seen that under conditions where both enzymes are synthesized, a mutual stimulation occurs. That is, in the presence of nitrate and galactose, both nitrate reductase and β-galactosidase are synthesized at a more rapid rate and a higher total amount of enzyme is formed. This experiment has been reproduced a number of times. Further, it has been found that subsequent addition of the second inducer to either system after allowing single induction to proceed for 15–30 min. also results in increased production of both enzymes.

One possible explanation of these results is that galactose stimulates nitrate reductase by providing an additional carbon source and also by creating an additional demand for an electron transport system. However, the addition of glucose to a final level of 1 per cent in the nitrate system resulted in a slight inhibition of nitratase formation. The stimulation of β-galactosidase by nitrate might also be explained on the basis that nitrate reductase provides an electron transport system which allows more rapid dissimilation of galactose. Attempts to examine this possibility by substituting methylene blue and ferricyanide for nitrate were without success since these agents interfered with the colour test used for measuring β-galactosidase.

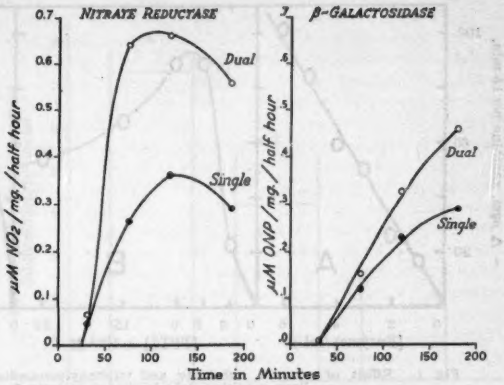

Fig. 1. Synthesis of nitrate reductase and β-galactosidase in the presence of homologous (single) and homologous plus heterologous (dual) inducers. See text and ref. 3 for details.

Under conditions of dual induction, decreasing the amino-acid concentration from 0·2 to 0·1 per cent suppressed β-galactosidase synthesis to a greater extent than nitrate reductase. These results are in accord with those of Wainwright and Neville[4], who attributed this difference in response to an ability of the organism (*E. coli* in their experiments) to utilize the reduced nitrate as a source of nitrogen. It might also be noted that Wainwright and Neville also found that tetrathionase induction appeared to stimulate induction of β-galactosidase; however, no results were shown. Studies are now under way to determine what priority, if any, may exist in the dual induction system under limiting conditions. These and other results will be published in detail elsewhere.

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A Photometric Method for Avian Liver Xanthine Dehydrogenase

A photometric method for chicken liver xanthine dehydrogenase based on the colorimetric determination of substrate disappearance[1] has been developed. It has been demonstrated to be very sensitive by comparative measurements of liver xanthine dehydrogenase using the manometric technique[2] during protein depletion and repletion.

Livers from thoroughly exsanguinated birds were removed immediately and chilled on ice. A portion was homogenized[1] and centrifuged at 24,000*g* for 40 min. at 0–3° C., yielding a clear supernatant. Use of a supernatant fraction in lieu of homogenate

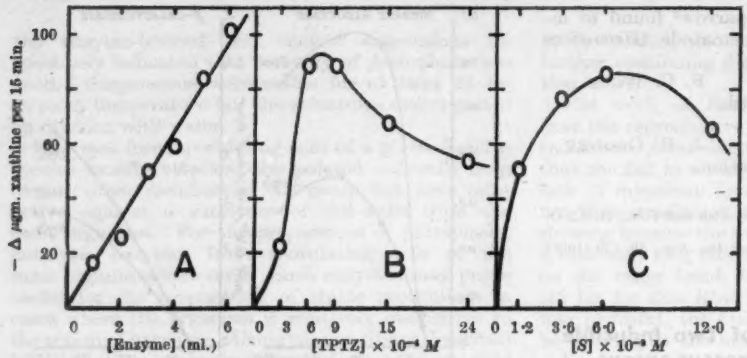

Fig. 1. Effect of enzyme, substrate and triphenyltetrazolium chloride concentration on liver xanthine dehydrogenase activity in the chick

improved the rate and uniformity of the catalytic reaction, eliminating about 35 per cent of the endogenous colour-forming material. Recovery of the added substrate at zero time averaged 97 per cent compared to 80 per cent using homogenates. Fig. 1,*A* demonstrates linearity between enzyme concentration and activity.

For reoxidation of the dehydrogenase[3], methylene blue[2] could not be used because of interference with the colorimetric determination of substrate; therefore, triphenyltetrazolium chloride, which is colourless under the assay conditions, was employed. Triphenyltetrazolium concentration is optimal at $7{\cdot}3 \times 10^{-4}$ *M* (Fig. 1,*B*). To link liver xanthine dehydrogenase to lactic dehydrogenase[4], oxidized diphosphopyridine nucleotide (5×10^{-3} *M*) was tested in the system. This addition was not considered essential since liver xanthine dehydrogenase activity of normal and depleted livers was equally improved (about 30 per cent).

To determine enzyme activity, stoppered 25-ml. Erlenmeyer flasks containing 5 ml. supernatant, 0·5 ml. triphenyltetrazolium (0·01 *M*) and, after a 10-min. pre-incubation period, 0·6 ml. xanthine solution (0·038 *M*) or water (control flasks) were shaken in a Dubnoff shaker at 37° C. at 190 oscillations per min. A final substrate concentration of $3{\cdot}6 \times 10^{-3}$ *M* was chosen. This level maintains approximately optimum activity during a 30-min. test (Fig. 1,*C*), whereas higher concentrations require extensive dilution of the aliquots for colorimetric assay.

After addition of substrate, each of the reaction mixtures was thoroughly shaken and a 1-ml. sample withdrawn within 10 sec. (zero time reading) and at 7·5, 15, 22·5 and 30 min. The reaction was rapidly stopped by pipetting the aliquots directly into 7 ml. of 40 per cent sodium tungstate, 2 *N* sulphuric acid and water (1 : 1 : 5). After 15 min. these tubes were diluted to 12 ml. with water and the concentration of xanthine determined[1]. Xanthine values obtained for the test flasks, corrected for endogenous activity (control flasks), are plotted against time. Comparable enzyme activity is calculated from the zero-order portion, which usually extends to 15 min. and is expressed by $-\Delta$ μgm. xanthine per 15 min.

Four-week old Lancaster and Columbian–New Hampshire chicks were used in a depletion–repletion study. They were raised on a commercial chick starter ration and then changed to a casein (7 or 21 per cent), fortified with glycine, arginine and methionine at 0·4, 0·2 and 0·04 per cent, 'Cerelose' diet adequately supplied with all known dietary essentials. At the start all birds received the control diet (21 per cent protein) for 4 days. Thereafter one group was changed to the 7 per cent protein diet. Enzyme activity was assayed on days indicated (Fig. 2). Body-weights of all birds were recorded at the beginning of the depletion period and at killing. Liver supernatant nitrogen was determined using semi-micro-Kjeldahl technique in duplicate.

Changes in liver xanthine dehydrogenase activity expressed on a nitrogen basis and body-weight are presented in Fig. 2, *A* and *B*. A comparison of liver xanthine dehydrogenase reduction in the bird with the behaviour of rat liver xanthine oxidase[5,6] shows the former to be less rapid and less extensive. About 40 per cent of total activity is lost during the first 4 days on a low protein diet, followed by an additional 25 per cent decrease in the next 10 days. When the higher protein-level is restored, enzyme activity is regained promptly. After 10–14 days of depletion, enzyme activity and growth are inhibited to about the same extent.

Supernatant enzyme activity determined manometrically[3] (Fig. 2, *A*) shows close agreement with

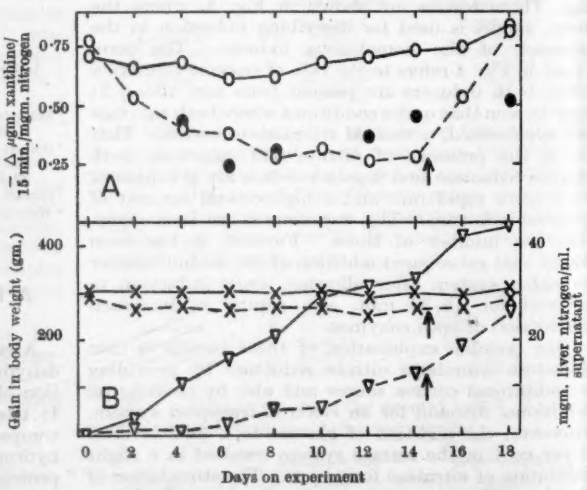

Fig. 2. Effect of low dietary protein intake on liver xanthine dehydrogenase activity, liver nitrogen and growth in the chick. ○, Enzyme activity determined colorimetrically; ●, enzyme activity determined manometrically; ▽, body-weight gain; ×, liver nitrogen. Solid lines represent the control group (21 per cent protein), broken lines the depleted group (7 per cent protein). The arrow indicates the point of repletion

the colorimetric method during depletion but seems less sensitive during repletion.

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Xanthine Oxidase Activity during Mammary Carcinogenesis in Mice

SOME hypothetical and empirical considerations that form the basis of our interest in xanthine oxidase have been stated in the first of a series of publications[1]. The investigations of the chemical properties of xanthine oxidase[1-3] have been extended to include the biological behaviour of this enzyme in normal and abnormal growth. The present communication deals with the xanthine oxidase activity in mammæ of mice of the *C* strain, with and without the milk factor, and in spontaneous mammary tumours. The studies of the enzyme activity in mammæ during pregnancy and lactation will be reported elsewhere.

The mice of the *C* strain without the milk factor will be referred to as *C*−. A sub-line of these mice (*C*+) was developed by incorporation of the milk factor through foster-nursing. The tumour incidence in *C*− virgins and breeders is practically nil, whereas the tumour incidence in *C*+ mice, while low in virgins, rises progressively to 100 per cent with the number of pregnancies. The spontaneous mammary tumours assayed were obtained from the *C*+ breeders.

The tissues were dispersed in a Potter–Elvehjem type of homogenizer with a Teflon pestle. The suspension medium (in the proportion of 9 ml. for each gm. of tissue) for the enzyme assay was 0·1 *M* pyrophosphate buffer (*p*H 8) and for the nuclear count was a solution containing sucrose (0·25 *M*) and calcium chloride (0·0018 *M*). The homogenate in the buffer was centrifuged at 20,000*g* for 30 min. at 0° C. and the clear supernatant was removed, avoiding the upper layer of fat, and incubated for 1 hr. at 37° C.

The enzyme assay[1], a modification of Kalckar's[4] method for determining purines, consisted in the spectrophotometric estimation of the rate of appearance of uric acid in the presence of xanthine ($2{\cdot}6 \times 10^{-4}$ *M*) as the substrate. Readings were obtained for 10 min. at 1-min. intervals at a constant temperature of 24° C. The enzyme activity was related to the cellularity of the tissue by dividing the activity per mgm. by the number of nuclei in a mgm. of fresh tissue. The nuclei were counted in a hæmocytometer after suitable dilution of the sucrose–calcium chloride homogenate in a solution of orcein-light green stain.

The results are summarized in Fig. 1, which shows the group averages and standard deviations of the enzyme activities in mammæ from *C*− virgin mice (group *A*), from *C*+ virgin mice (group *B*), and in mammary tumours from *C*+ breeders (group *C*). The amount of xanthine oxidized (or uric acid appearing) in micromoles × 10^{-5} per min. per 100,000 nuclei is 7·2, 4·1 and 1·8 for groups *A*, *B* and *C*, respectively. Relative to the xanthine oxidase activity in breasts from mice without the milk factor (group *A*), the activity in mammary tissue from mice with the milk factor (group *B*) is 57·7 per cent and in spontaneous mammary tumours (group *C*) 24·9 per cent. The differences of the average levels of enzyme activity are statistically highly significant, the *P* value being less than 0·001 by the *t*-test.

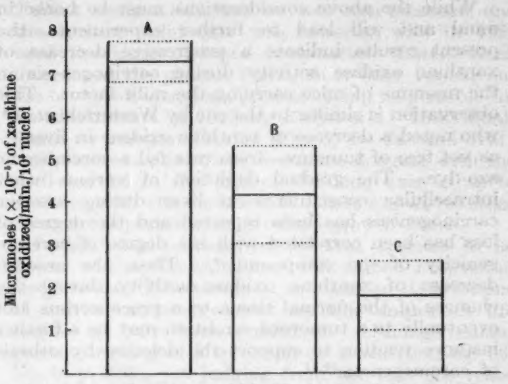

Fig. 1. Xanthine oxidase activity during carcinogenesis in mouse breast. *A*, Virgin breast from low-tumour strain (*C*−) without milk factor; 25 animals. *B*, Virgin breast from high-tumour strain (*C*+) with milk factor; 50 animals free of tumours. *C*, Spontaneous mammary tumour from mated (*C*+) mice; 24 animals. (Dotted line indicates ± S.D.)

It is of interest to mention that the xanthine oxidase activity in mammæ from multiparous, cancer-prone *C*+ breeders, whether they have or have not yet developed mammary carcinoma, is practically the same as in mammæ from *C*+ virgins which usually do not develop tumours. No appreciable difference in xanthine oxidase activity could be detected in livers from *C*− and *C*+ mice. In contrast to the progressive decrease in the activity of xanthine oxidase associated with the events which predispose to and finally result in abnormal growth (Fig. 1), it was found that during pregnancy the enzyme activity in the growing breast pads of *C*+ mice increased markedly.

The interpretation of the results shown in Fig. 1 is as yet difficult, since a number of conditions must be considered which need clarification. The activity measured by enzyme assays *in vitro* does not necessarily reflect the biological activity within the intact cell, since such limiting factors as substrate concentration, the nature and concentration of activators and inhibitors *in vivo* are not known. Moreover, the activity per cell, as here expressed, is an average value for all cells in the homogenate and does not reveal localized changes in enzyme activity. A spotty distribution of foci of cells with low or no enzyme activity surrounded by normal cells would be possible and has been reported for antigenic cell constituents[5]. Furthermore, it should be pointed out that, although the *C*− and *C*+ mice originated from the same genetic stock, prolonged inbreeding within the sub-lines may have resulted in a genetic difference. Thus, the difference in xanthine oxidase activity in mammæ of group *A* and *B* (Fig. 1) may not be due solely to the incorporation of the milk factor.

While the above considerations must be borne in mind and will lead to further experiments, the present results indicate a progressive decrease of xanthine oxidase activity during carcinogenesis in the mammæ of mice carrying the milk factor. This observation is similar to the one by Westerfeld *et al.*[6], who noted a decrease of xanthine oxidase in livers—as yet free of tumours—from rats fed a carcinogenic azo-dye. The gradual depletion of various other intracellular constituents in liver during azo-dye carcinogenesis has been reported and the degree of loss has been correlated with the degree of carcinogenicity of the compound[7-9]. Thus, the gradual decrease of xanthine oxidase activity during the changes of the normal tissue to a precancerous and eventually to a tumorous condition may be a further instance tending to support the deletion hypothesis of carcinogenesis[10,11].

We thank Profs. A. Haddow and F. Bergel for their interest and encouragement throughout this investigation, which was supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research: Royal Cancer Hospital) from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund, and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

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The Polyhedral Virus of *Heliothis armigera* (Hbn.) (Lepidoptera : Noctuidae)

According to Steinhaus[1], Mally[2] may have been the first to mention in 1891 a wilt disease in *Heliothis armigera* (Hbn.). Later reports of this disease came from Glaser and Chapman[3], Parsons[4], and Stahler[5]. Because of the economic importance of this insect and the possible use of the virus for control purposes it was decided to investigate the causative agent.

The larvæ used in this investigation died, presumably of a virus disease, in rearings of this insect carried out by G. Marcos at the Gezira Research Farm of the Ministry of Agriculture of the Sudan in the autumn of 1956. Two samples containing about twenty and five dried larvæ were submitted. The diagnosis with the light microscope revealed the presence of large numbers of bacteria, but only the five larvæ of the small sample showed several small polyhedra. The five larvæ were crushed and suspended in water for some weeks. This suspension was filtered through fine 'Orlon' mesh and the remnants thoroughly washed to save as many polyhedra as possible. The latter were purified by differential centrifuging. Due to the small size sample, only a few mgm. of an impure polyhedral preparation could be obtained.

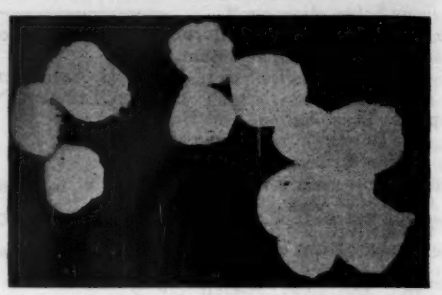

Fig. 1. Polyhedral bodies of *Heliothis armigera*. (× 10,000)

The examination of this polyhedral preparation in the electron microscope revealed that the polyhedra are of irregular shape and vary in diameter from 0·7 to 1·2μ, the majority measuring about 1·1μ (Fig. 1). Apart from these polyhedra a few smaller, ovoid forms could be observed which might be capsular inclusion bodies. However, it was impossible to decide the identity of these forms with capsules.

The virus particles were liberated from the polyhedra and purified according to the standard method[6]. However, owing to the impurity and scarcity of the sample it was not possible to determine accurately the alkali concentration necessary to obtain highly infective particles. The dissolution of 1 mgm. of polyhedra in 0·2 ml. of a mixture of 0·01 *M* sodium carbonate + 0·05 *M* sodium chloride was used. These polyhedral suspensions became rather brownish during the dissolution period of three hours, and a heavy brownish sediment of impurities resulted from sedimentation at 4,000 r.p.m. (3,000*g*) for five minutes. The slightly turbid supernatant, consisting of polyhedral protein and virus particles, was sedimented for one hour at 11,000 r.p.m. (10,000*g*). The small yellow-white sediment of virus particles was re-suspended in 0·2 ml. distilled water and again spun for one hour at 11,000 r.p.m. The final sediment was well drained and suspended in 70 μl. (one-seventh of its original volume) and diluted 1 to 5 with distilled water before applying to the electron microscope grids.

The investigation in the electron microscope showed that the virus is rod-shaped and occurs mainly in single rods (Fig. 2). It is a typical representative of classical polyhedral virus of the *Borrelina* group and the name *Borrelina armigera* is suggested. Several micrographs revealed that this virus has all the typical morphological differentiations (developmental and intimate membranes, spherical stages, etc.) characteristic of this group. There are very few virus bundles, and these contain most likely only two rods, similar to the *Bombyx mori* L. polyhedral virus. The average dimensions of the single virus rods still possessing the developmental membrane are about 320 ± 10 mμ × 90 ± 10 mμ. For technical reasons it was impossible to test the infectivity of this

Fig. 2. Virus particles liberated from *Heliothis armigera* polyhedra. (× 50,000)

virus preparation but there is no doubt that the rods are the causative agent. The micrographs suggest further that the alkali concentration for the dissolution of the impure polyhedra was too high, since many virus particles had lost their developmental and part of their intimate membranes. It can be assumed by analogy with other viruses of this group that virus particles without membranes have lost their power to infect. It is further suggested that the proper alkali concentration for dissolution of *H. armigera* polyhedra should be less than 0·01 *M*, probably about 0·008 *M*, sodium carbonate. The lack of material did not permit us to check this point accurately.

The condition of the submitted larvæ made it impossible to decide in what tissue the polyhedra develop and whether it is a nuclear or cytoplasmic polyhedrosis. However, by analogy with other insect viruses, it is likely that the rod-shaped particles are the causative agent of a nuclear polyhedrosis. The possible presence of a granulosis is at present being investigated.

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Enigmonia aenigmatica Sowerby, a Motile Anomiid (Saddle Oyster)

Among the most obscure of marine bivalves are the elongated anomiids which occur on the leaves and exposed roots of mangroves over an uncertain area in the tropical central Indo–Pacific, but certainly ranging from Malaya to the Philippines and to north-east Australia. According to Iredale[1], the original description, based on a single valve from the East Indies, is that of Chemnitz in 1795. He named it *Tellina aenigmatica*, but he was non-binomial and the earliest valid user was Sowerby, who in 1825 used the name *Anomia aenigmatica*. Later, Koch introduced the generic name, as it later turned out pre-occupied, *Aenigma*, Iredale[2] being responsible for its substitution in 1918 by *Enigmonia*. Individuals found on mangrove leaves (Fig. 1) are flat and oval; those on stems and roots are more elongate with the shell curved in the line of the long axis so as to conform with the surface. It is not known whether these are separate species or are growth forms.

Iredale[1] has summarized all that appears to be known about this animal so well named *Enigmonia aenigmatica*. Knowledge is confined to descriptions of valves; no observations on this animal in life appear to have been published. Although Allan[3] gives a drawing of a specimen on a leaf (text-fig. 66, No. 9, p. 283), yet judging from her text she relies entirely on Iredale's earlier account, the drawing not having been made from life nor, apparently, being of an animal actually attached to a leaf.

My attention was directed to the presence of this species around the coasts of Singapore Island and of Malaya by Prof. R. D. Purchon during August 1956. I failed to secure living specimens; but later my colleague, Mr. Gareth Owen, returning from New Zealand by way of Singapore, was more fortunate and collected two on mangrove leaves which I later examined alive in Glasgow. Later, Prof. Purchon sent preserved specimens, including individuals attached to stems. I am most grateful to Prof. Purchon and to Mr. Owen for this apparently first opportunity of examining alive a lamellibranch mollusc of such unusual interest.

It turns out that *E. aenigmatica* is a motile anomiid. As shown in Fig. 1, it possesses a long foot, flat and ribbon-like except for an attenuated terminal region like a filament which is pointed and round in section. This is very active and gives the impression of having tactile functions. The flattened region of the foot can extend for more than half the length of the shell; with this the animal crawls actively over the surface of a mangrove leaf as it is shown doing in the figure or, with no less facility, on the glass sides of an aquarium. In movement the foot appears to flow, the distal region (excluding the filament) spreading out and then acting as a sucker which grips the substratum while the pedal muscles, which can be seen through the translucent tissues, contract and draw the animal forward. If the shell is turned upside down the foot twists so that the sole remains on the under side; this grips the surface and eventually the animal is pulled over on to the right valve. Apart from being elongate the shell is that of a typical anomiid, that is, with the deep embayment of the mantle/shell in the under, right mantle lobe and shell valve. General disposition of the organs and the direction of ciliary currents on the ctenidia, palps and in the mantle cavity are all essentially the same

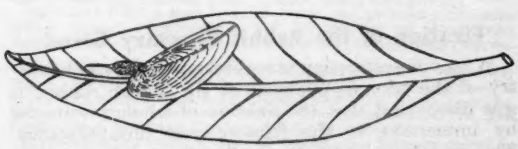

Fig. 1. *Enigmonia aenigmatica* (× 4) with foot extended crawling over mangrove leaf

as those described by Atkins[4] for *Heteranomia squamula* and *Monia squama*. Differences are in the great development of the foot with resumption of its original function, in the temporary nature of byssal attachment and in the greater modification of the shell.

Despite their immobility the foot never disappears in the anomiids, neither in byssal-attached species of *Anomia* (covering various subgenera such as the British *Heteramonia* and *Monia*) nor the window-pane shells of the closely allied genera *Placenta* (*Placuna*) and *Ephippium*, which live, immobile on the surface of mud or sand, also resting on the right valve, which has there no embayment. The foot, as in other immobile lamellibranchs where it is also retained, for example, *Spondylus*, assists in cleansing the mantle cavity. It is never lost, as it is, for example, in the Ostreacea, and there is nothing to prevent its hypertrophy and use again as an organ of locomotion in *E. aenigmonia*.

From time to time the foot was observed to withdraw. When seen through a glass surface to which the animal was attached, contact appeared then to be made by way of a sucker-like ribbed surface. Further examination showed this to be the byssal opening, and attachment to be due to secretion of a transparent byssal material. The animal has no difficulty in breaking this very temporary attachment. The condition in the specimens living upon roots and stems, where attachment does appear to be more permanent, still awaits examination.

Although lying on its side with the left valve uppermost, this bivalve, as shown in Fig. 1, has the habits and to some extent the appearance of an elongated limpet. The appearance is due to the manner in which the umbo, which represents the highest point of the shell, like the apex of a limpet, has withdrawn from the margin. This is a consequence of the extension of the mantle lobes 'dorsally' on either side of the mantle isthmus so that they surround the ligament and meet 'dorsal' to this. The ligament becomes an island connecting the two valves which extend beyond it 'dorsally' as well as 'ventrally'. The same process takes place in all anomiids but not to the same extent as in *Enigmonia*.

As in all such instances, therefore, we are seeing in *Enigmonia aenigmatica* the realization of potentialities—however far from initially apparent these may be—which are latent in the parent anomiid stock. The opportunity is being taken, when giving a fuller account of this most interesting lamellibranch, of re-investigating form in the Anomiacea.

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Fixation of the Rabbit Pituitary Gland

While investigating the cytology and cytochemistry of the adenohypophysis of the female rabbit, it was discovered that the fixation of whole pituitaries by immersion in the fixative was unsatisfactory. The reaction of the basophil cells to the periodic acid–Schiff procedure and to the Gram technique was extremely inconstant. It was clear that the total number of basophils was not being demonstrated and there was often much diffuse coloration of cells the exact nature of which it was difficult to determine. Commonly, also, a peripheral rind of distorted cells was produced, the staining of which was atypical.

Since serial sections of the complete pituitary were required, fixation by freeze-drying was unsuitable. In consequence, fixation by vascular perfusion was adopted. The animal was anæsthetized with nembutal given intraperitoneally (intravenous injection caused extensive cell damage, evidently owing to vascular spasm): it was then perfused into the left ventricle at a controlled pressure. Direct perfusion with a non-precipitant fixative without previous washing out of the blood gave very poor fixation. The effect of preliminary perfusion with several fluids was then compared, namely, Ringer's fluid, 0·25 *M* sucrose, saline and Ringer's solution both buffered to *p*H 4·5 (this being near the isoelectric point of the pituitary glycoproteins of some other species[1,2]). These were followed by perfusion with neutral formalin, formal-sublimate or Helly's fluid. None of these procedures was successful in preserving adequately the glycoprotein of the basophil cells and the general fixation of the adenohypophysis was extremely variable, areas of distorted and disrupted cells being frequently encountered. The degree of dilatation of the sinusoids also varied widely. A perfusion pressure of 80 mm. mercury was used in these experiments.

Finally we decided to use, for the preliminary washing out, a fluid more comparable physiologically with plasma but which would not be coagulated by the ensuing fixative. A commercial preparation, 'Dextraven' (6 per cent w/v dextran in 5 per cent dextrose), was employed, at a perfusion pressure of 50–60 mm. mercury. It was hoped that this would prevent loss of glycoprotein, and that there would be no serious non-specific absorption of periodic acid–Schiff positive carbohydrate from the perfusion fluid itself. We found that the distortion effects were greatly reduced, and, when 'Dextraven' was followed by a mixture of neutral formalin, calcium and cadmium chlorides, excellent preservation of the glycoprotein resulted, allowing brilliant staining by the periodic acid–Schiff technique. There was some non-specific absorption of carbohydrate in the sinusoidal lining cells, but elsewhere it was very slight and, in the acidophils, absent. It is not claimed that this method is always successful in preserving all the glycoprotein material, since it has not yet been possible to control all the variables involved: but we consider that with it a more accurate picture of the basophil cells can be obtained than by the usual method of fixation by immersion. The extent of the zona tuberalis is also more clearly defined.

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FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, October 14

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Gustave Tuck Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. R. O. Kapp: "Ockham's Razor and the Unification of Physical Science" (Chairman's Address).

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "The Social Consequences of Automation", opened by the President.

ROYAL INSTITUTE OF CHEMISTRY (at Ewell County Technical College, Reigate Road, Ewell, Surrey), at 7 p.m.—Dr. A. H. Cook, F.R.S.: "Chemical Problems in the Brewing Industry".

Monday, October 14—Tuesday, October 15

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (joint meeting with the CHEMICAL ENGINEERING GROUP, at the Royal Institution, Albemarle Street, London, W.1), at 2 p.m. Monday and 9.30 a.m. Tuesday—Symposium on "Safety in Chemical Industry".

Tuesday, October 15

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (at 14 Belgrave Square, London, S.W.1), at 10.30 a.m.—Phosphorus Meeting.

UNIVERSITY COLLEGE, LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. J. F. M. Middleton: "Witches and Sorcerers".*

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS (at the Institution of Electrical Engineers, Savoy Place, London, W.C.2), at 5 p.m.—Chairman's Address: "30 Years of Radio Development in the Post Office".

INSTITUTE OF PHYSICS, ELECTRONICS GROUP (at 47 Belgrave Square, London, S.W.1), at 5.30 p.m.—Dr. B. Meltzer: "Dense Electron Beams".

INSTITUTION OF CIVIL ENGINEERS (at Great George Street, London, S.W.1), at 5.30 p.m.—Mr. F. L. Harwood and Mr. K. C. Wilson: "An Investigation into a proposal to Dispose of Power Station Ash by Discharging it into the Sea at Low Water".

PHYSICAL SOCIETY, ACOUSTICS GROUP (in the Physics Lecture Theatre, Imperial College, Imperial Institute Road, London, S.W.7), at 5.30 p.m.—Dr. M. Redwood: "The Propagation of Compressional Waves in Solids at Frequencies between 10 and 100 Mc./sec. and the Measurement of their Absorption".

Tuesday, October 15—Wednesday, October 16

THE CORROSION CONVENTION (at the Central Hall, Westminster, London, S.W.1). (Organized by *Corrosion Technology* and the Leonard Hill Technical Group.)

Wednesday, October 16

WATER RESEARCH ASSOCIATION (at the Royal Society of Arts, John Adam Street, London, W.C.2), at 2.30 p.m.—Discussion on the Work of the Association. Chairman: Mr. Norman J. Pugh.

INSTITUTE OF NAVIGATION (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 3 p.m.—Annual General Meeting. Capt. A. M. A. Majendie: "The Display and Use of Navigational Intelligence" (Presidential Address).

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, South Kensington, London, S.W.7), at 5 p.m.—Dr. C. H. B. Priestley: "The Work of the Division of Meteorological Physics, Commonwealth Scientific Research Organization, Victoria, Australia".

ROYAL SOCIETY OF MEDICINE, COMPARATIVE MEDICINE SECTION (at 1 Wimpole Street, London, W.1), at 5 p.m.—Dr. J. B. Brooksby: "Comparative Aspects in Virology" (Presidential Address).

BRITISH COAL UTILIZATION RESEARCH ASSOCIATION (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Monsieur Raymond Cheradame: "From Coal to Coke" (Sixth Coal Science Lecture).

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. J. S. McPetrie: "Some Radio Aids for High-Speed Aircraft" (Chairman's Address).

ROYAL INSTITUTE OF CHEMISTRY (at King's College, Strand, London, W.C.2), at 6.30 p.m.—Dr. H. M. N. H. Irving: "Solvent Extraction in Inorganic Chemistry".

RADAR ASSOCIATION (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 7.30 p.m.—Dr. Robin A. Smith: "Physics and Radar".

Thursday, October 17

INSTITUTION OF MINING AND METALLURGY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. J. M. Caw: "Control of Air Pressure as an Aid to Fight Mine Fires"; Mr. S. W. K. Morgan: "The Production of Zinc in a Blast Furnace".

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDING MATERIALS GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. J. S. Hughes and Mr. P. A. Griffin: "Silicones and the Treatment of Road and Building Materials".

CHEMICAL SOCIETY (in the Large Chemistry Lecture Theatre, Imperial College of Science and Technology, South Kensington, London, S.W.7), at 7.30 p.m.—Prof. R. M. Barrer, F.R.S.: "Crystalline Ion Exchangers" (Tilden Lecture).

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Brigadier J. S. K. Boyd, O.B.E., F.R.S.: "Dysentery—Some Personal Experiences and Observations" (Presidential Address).

Friday, October 18

BRITISH ORNITHOLOGISTS' UNION (in the Lecture Hall of the British Museum (Natural History), Cromwell Road, London, S.W.7), at 6 p.m.—Annual Scientific Meeting. Dr. N. Tinbergen: "Camouflage, Warning Colours, and Predators", illustrated by slides and a film.

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Sir George Nelson, Bt.: Presidential Address.

Saturday, October 19

BIOCHEMICAL SOCIETY (in the Physiology Lecture Theatre, Guy's Hospital Medical School, London, S.E.1), at 2 p.m.—Scientific Papers.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

RESEARCH STUDENT, for research in internal combustion engineering or a related subject—The Registrar, King's College, Strand, London, W.C.2 (October 15).

PATHOLOGIST (with a diploma in clinical pathology or higher degree in pathology, and preferably additional experience in histopathology) IN THE PATHOLOGICAL LABORATORIES, Department of Public Health, New South Wales, Australia—The Agent General for New South Wales, 56 Strand, London, W.C.2 (October 18).

ASSISTANT, Grade B (with a good honours degree, and preferably with teaching and/or research experience), to teach mathematics to B.Sc. general standard—The Principal, Norwood Technical College, Knight's Hill, London, S.E.27 (October 19).

RESEARCH ASSISTANT IN THE DEPARTMENT OF PHYSICS, to take part in research, under the direction of the Head of the Department, leading to the development of solid-state image amplifiers—The Registrar, The University, Hull (October 19).

VETERINARY SURGEON IN THE EXPERIMENTAL PATHOLOGY DEPARTMENT, for assistance with clinical and pathological work, with opportunities for research in experimental pathology—The Secretary, Institute of Animal Physiology, Babraham, Cambridge (October 19).

ASSISTANT LIBRARIAN (chartered librarian, preferably F.L.A., with experience of technical college, university, or public library work) at the Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 1 Woburn Square, London, W.C.1 (October 21).

LECTURER IN GEOGRAPHY (with special reference to survey)—The Secretary of University Court, The University, Glasgow (October 21).

LECTURER IN MATHEMATICS; a LECTURER IN CHEMISTRY; and a LECTURER IN PHYSICS at the Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 1 Woburn Square, London, W.C.1 (October 21).

EDUCATIONAL PSYCHOLOGIST (with a suitable degree and appropriate experience, including at least two years teaching)—The Director of Education, Shire Hall, Bedford (October 25).

PHYSICIST-IN-CHARGE OF THE PHYSICS DEPARTMENT—The Group-Secretary, General Hospital, Nottingham (October 26).

CIVIL OR MECHANICAL ENGINEERS, Scientific Officer grade (with a first- or second-class honours degree in appropriate subjects) at the Hydraulics Research Station, (D.S.I.R.), Wallingford, Berks, for hydraulic research, including work on models—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Ref. E.74/7A (October 29).

ASSISTANT IN THE DEPARTMENT OF LOGIC AND METAPHYSICS in St. Salvator's College—Joint Clerk to the University Court, College Gate, St. Andrews (October 31).

ASSISTANT LECTURER (with an honours degree) IN PSYCHOLOGY at Canterbury University College, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, October 31).

HEAD (well-qualified graduate of a British university) OF THE ELECTRICAL ENGINEERING DEPARTMENT—The Clerk to the Governing Body, Battersea College of Technology, London, S.W.11 (October 31).

LABORATORY TECHNICIAN IN THE CLINICAL VETERINARY SCHOOL, Kabete, Kenya (Makerere College—University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (October 31).

READER (with high academic qualifications) IN EITHER BOTANY OR ZOOLOGY—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (October 31).

LECTURER (with a good honours degree, and preferably industrial and/or research experience) IN THE DEPARTMENT OF MECHANICAL ENGINEERING—The Registrar, The University, Southampton (November 1).

LIVESTOCK RESEARCH OFFICER (POULTRY) (with a university degree, preferably in veterinary, agricultural or pure science) at Seven Hills Poultry Experiment Station, New South Wales, Australia, to concentrate on genetical studies—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (November 1).

MATHEMATICIAN (with a first- or second-class honours degree in mathematics) AT THE HYDRAULICS RESEARCH STATION, D.S.I.R., Wallingford, Berks, to lead a small section for theoretical studies in hydrodynamics and advise other sections of the Station which deal mainly with open-channel hydraulics and wave action—The Ministry

of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.290/7A (November 2).

Lecturer in Astronomy—The Secretary of University Court, The University, Glasgow (November 4).

Lecturer (with an honours or higher degree in zoology and preferably some experience in university teaching) in Zoology at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 8).

Lecturer, Grade I or Grade II (with a degree with high honours in engineering, physics or mathematics, and experience or an interest in the theoretical and experimental aspects of fluid mechanics), in Aeronautical Engineering—The Registrar, The University, Bristol 8 (November 15).

Chemist (with a good honours degree in inorganic chemistry or equivalent) in the Geological Survey Department, Government of Tanganyika, for the analysis of rocks, minerals and ores, and to supervise junior staff in routine analytical work—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/8/09.

Experimental Officer or Assistant Experimental Officer (with G.C.E. ("A" level) or H.N.C. or equivalent, some experience of physical chemical methods, and preferably a knowledge of metallurgical techniques), to investigate applications of radiotracers to problems in physical chemistry, with particular reference to the study of solids—Recruitment (936Z/34), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Laboratory Technician (Physiologist) (aged 24–40, possessing A.I.M.L.T. preferably in bacteriology, or equivalent, and a good practical knowledge of physiological laboratory technology), with the East African Veterinary Research Organization (East Africa High Commission)—The Crown Agents, 4 Millbank, London, S.W.1, quoting M.3/43369/NF.

Principal of the University College of Wales, Aberystwyth—The Registrar, University College of Wales, Aberystwyth.

Seed Production Officer (with a recognized degree in agriculture, horticulture or an allied subject, and considerable postgraduate experience in seed production work, preferably with a private seed enterprise, and good administrative ability) in Cyprus, to administer the Seed Production Section of the Department of Agriculture and to supervise the production of cereal (wheat and barley), forage, lucerne, vetch, Egyptian clover, etc., vegetable and flower seeds for both local requirements and export—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD/63/17/03.

Senior Experimental Officer and Experimental Officer, for work relating to the criticality of fissile assemblies, fast reactor systems, and general neutron physics research including measurements with a pulsed particle accelerator; and an Experimental Officer or an Assistant Experimental Officer, to work initially as a member of a team engaged on preliminary zero energy experiments leading to the commissioning of a research reactor, and later on experimental reactor physics—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. 1582/34.

Senior Laboratory Technician for the Nuclear Science Laboratories in the Department of Electrical Engineering and Physics—The Secretary, Borough Polytechnic, Borough Road, London, S.E.1.

Senior Lecturer (preferably with a higher degree in geology and teaching experience) in Geology at the University College, Mandalay, Burma—The Ministry of Labour and National Service (E.9), 26–28 King Street, London, S.W.1, quoting A.12/BUR/TCS/218.

Senior Lecturer (preferably with industrial and/or research experience) in the Department of Mechanical Engineering—The Principal, Royal Technical College, Salford.

Technician (preferably with a knowledge of chemistry and electrical apparatus) in the Zoology Department, to work in the Physiological Laboratory—The Registrar, The University, Nottingham.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Society for the Promotion of Nature Reserves. Handbook 1957: Fortieth Annual Report year ending 31st March, 1957. Pp. 43+8 plates. (London: Society for the Promotion of Nature Reserves. 1957.) 5*s*. [297

Forestry Commission. Report on Forest Research for the year ended March, 1956. Pp. vii+172. 6*s*. net. Leaflet No. 3: Pine Shoot Beetles. Pp. 9. 8*d*. (London: H.M. Stationery Office, 1957.) [297

British Chemicals and their Manufacturers, 1957: The Directory of the Association of British Chemical Manufacturers. Pp. 200. (London: Association of British Chemical Manufacturers, 1957.) [297

Abbreviated Proceedings of the Oxford Mathematical Conference for Schoolteachers and Industrialists, Trinity College, Oxford, April 8–18, 1957. Pp. 112. (London: *Technology*, The Times Publishing Company, Ltd., 1957.) 2*s*. 6*d*. [297

Ministry of Agriculture, Fisheries and Food. Fishery Investigations. Series 2, Vol. 20, No. 10: Benthic Animals as Indicators of Hydrographic Conditions and Climatic Change in Svalbard Waters. By R. W. Blacker. Pp. ii+50+20 tables. (London: H.M. Stationery Office, 1957.) 22*s*. 6*d*. net. [297

Size and Morale, Part 2: a Further Study of Attendance at Work in Large and Small Units. Pp. ii+36. (London: The Acton Society Trust, 1957.) 3*s*. 6*d*. [297

United Kingdom Atomic Energy Authority. Third Annual Report for the period 1st April 1956–31st March 1957. Pp. vi+58. (London: H.M. Stationery Office, 1957.) 3*s*. net. [297

F.B.I. Overseas Scholarships: Third Annual Report for the year ended 31 March 1957. Pp. 26. (London: Federation of British Industries, 1957.) [297

British Rubber Producers' Research Association, Nineteenth Annual Report, 1956. Pp. 44. (London: British Rubber Producers' Research Association, 1957.) [297

Institute of Physics. Thirty-seventh Annual Report, 1956. Pp. 20. (London: Institute of Physics, 1957.) [297

Department of Scientific and Industrial Research: Geological Survey and Museum. A Guide to the Geological Column exhibited in the Museum of Practical Geology. By the late Dr. R. L. Sherlock. Second edition. Pp. ii+6. (London: H.M. Stationery Office, 1957.) 9*d*. net. [78

Ministry of Agriculture, Fisheries and Food. Fishery Investigations. Series 2, Vol. 21, No. 4: The Biology of *Pandalus montagui* Leach. By M. N. Mistakidis. Pp. iii+52+8 plates. (London: H.M. Stationery Office, 1957.) 14*s*. net. [78

Council for the Preservation of Rural England. Thirty-first Annual Report, 1956–1957. (Vol. 16, No. 5.) Pp. 56+4 plates. (London: Council for the Preservation of Rural England, 1957.) [78

Air Ministry: Meteorological Office. Professional Notes, No. 121: A Statistical Study of the Variation of Wind with Height. By C. S. Durst. Pp. 10. (M.O. 623a.) (London: H.M. Stationery Office, 1957.) 8*d*. net. [78

Institute of Biology. A Directory of Independent Consultants in Biology. Second edition. Pp. 4. (London: Institute of Biology, 1957.) [78

Bulletins of Marine Ecology (formerly Hull Bulletins of Marine Ecology). No. 37, Vol. 4 (June 1957): Continuous Plankton Records: The Distribution of *Calanus Finmarchicus* (Gunn) in the North Sea and North-Eastern Atlantic, 1946–1953. By the late Dr. C. B. Rees. Pp. 211–246. (Edinburgh: Scottish Marine Biological Association, 1957.) 12*s*. [78

Other Countries

Journal of Molecular Spectroscopy. Vol. 1, No. 1 (July, 1957). Pp. 80. Publishd bimonthly. Subscription rate: 10 dollars for 4 issues. Single Issues: 3 dollars. (New York: Academic Press, Inc., 1957.) [297

Annals of Physics. Vol. 1, No. 1 (April, 1957). Pp. 112. Published monthly. Subscription rates: Vol. 1 (3 issues) 8 dollars; Vol. 2 (6 Issues) 14 dollars. Single Issues: 3 dollars. (New York: Academic Press, Inc., 1957.) [297

Union of South Africa: Department of Commerce and Industry. Investigational Report No. 25: The South African Pilchard (*Sardinops ocellata*) and Maasbanker (*Trachurus trachurus*). Variations in the Phytoplankton of the St. Helena Bay Area during 1954. By B. v. D. de Jager. Pp. 78. (Reprint from *Commerce and Industry*.) (Pretoria: Government Printer, 1957.) [297

Tenth Annual Report of the Pacific Science Board, 1956. Pp. 50. (Washington, D.C.: National Academy of Science—National Research Council, 1957.) [297

Advantages from Research in Mellon Institute, 1956–1957. Pp. vi+54. (Annual Report Series, No. 44.) (Pittsburgh: Mellon Institute, 1957.) [297

Annals of the New York Academy of Sciences. Vol. 71, Article 1 (July 10, 1957): The Effects of the Sulfonylureas and Related Compounds in Experimental and Clinical Diabetes. By Rachmiel Levine and 92 other Authors. Pp. 292. (New York: New York Academy of Science, 1957.) 4 dollars. [297

United States Naval Observatory. Circular No. 75: Positions, Areas, and Counts of Sunspots, November, 1956. By Winifred Sawtell Cameron. Pp. 12. Circular No. 76: Positions, Areas, and Counts of Sunspots, December, 1956. By Winifred Sawtell Cameron. Pp. 12. Circular No. 77: Solar Summary for 1956. Pp. 40. (Washington, D.C.: United States Naval Observatory, 1957.) [297

Société de Physique et d'Histoire Naturelle de Genève. Archives des Sciences. Vol. 10 (Fascicule spécial): 6e. Colloque Ampère, Rennes-St.-Malo, 24, 25 avril, 1957. Pp. 296. (Genève: Librairie de l'Université Georg et Cie., S.A., 1957.) [78

Canada: Department of Agriculture. Annual Report of the Forest Insect and Disease Survey, 1957. Pp. 95. (Ottawa: Queen's Printer, 1957.) [78

Danmarks Fiskeri-og Havundersøgelser. Skrifter, Nr. 17: Fiskeri undersøgelser i 1956 ved Danmark, Færøerne og Grønland. Ved Å. Vedel Tåning og Paul M. Hansen. Pp. 32. 3 Kr. Meddelelser. Ny Serie. Bind 1, Nr. 11: The Deep Sea Prawn (*Pandalus borealis* Kr.) in Greenland Waters. By Svend Aage Horsted and Erik Smidt. Pp. 118. 25 Kr. (København: C. A. Reitzels Forlag, 1957.) [78

World Health Organization. Technical Report Series, No. 129: General Principles Governing the use of Food Additives—First Report of the Joint FAO/WHO Expert Committee on Food Additives. Pp. v+22. (Geneva: World Health Organization; London: H.M. Stationery Office, 1957.) 1 Swiss franc; 1*s*. 9*d*.; 0.30 dollars. [78

Rockefeller Institute Quarterly. Vol. 1, No. 1 (March, 1957). Pp. 8. (New York: The Rockefeller Institute for Medical Research, 1957.) [78

Geological Survey of Uganda. Water Supply Paper No. 3: Domestic Water Supplies in Rural Areas. By Dr. N. Harris. Pp. 4+3 plates. (Entebbe: Government Printer, 1957.) 1*s*. [78

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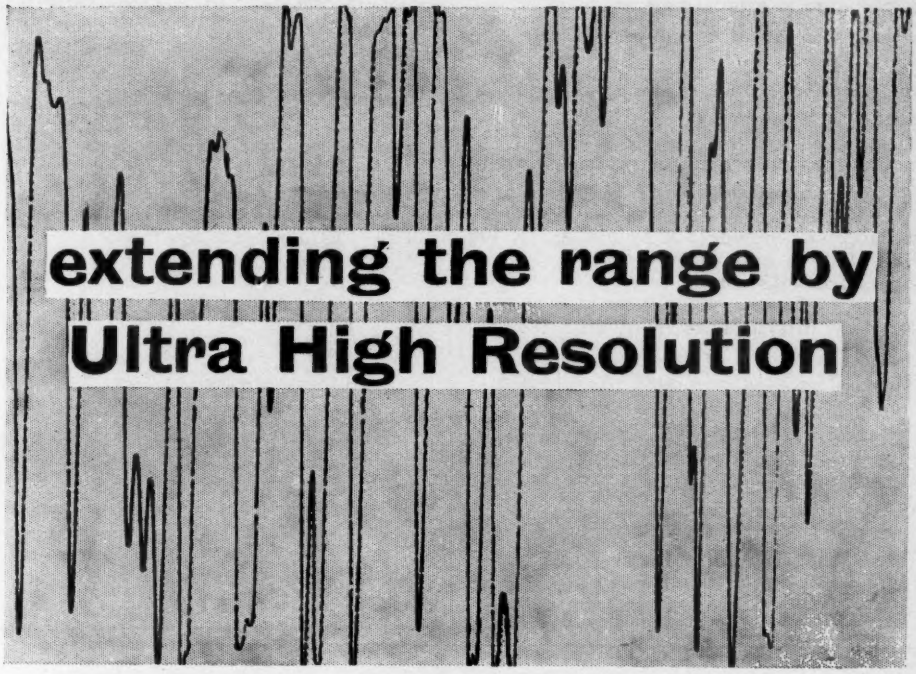

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